









# MEMOIRS

OF THE

# NATIONAL ACADEMY OF SCIENCES.

---

## Volume IX.

---

WASHINGTON:

GOVERNMENT PRINTING OFFICE

1905.



gQh  
6561  
BbP2X  
V12  
Ento

---

---

NATIONAL ACADEMY OF SCIENCES.

---

VOLUME IX.

---

MONOGRAPH OF THE BOMBYCINE MOTHS OF NORTH AMERICA, INCLUDING  
THEIR TRANSFORMATIONS AND ORIGIN OF THE LARVAL  
MARKINGS AND ARMATURE.

---

PART II.

FAMILY CERATOCAMPIDÆ, SUBFAMILY CERATOCAMPINÆ.

BY

ALPHEUS SPRING PACKARD.

(1)

1905.

---

1





## CONTENTS.

---

	Page
I. Coloration and protective attitudes of the Notodontidae.....	5
II. The larval armature of the Ceratocampinae .....	10
III. The caudal horn of the Ceratocampidae.....	17
IV. Protective armature both in shape and color and defensive movements .....	22
V. Coloration in the larvae of the Ceratocampinae.....	22
VI. Dichromatism or color variation in the larva.....	26
VII. Life history of <i>Ceratomia amyntor</i> .....	30
VIII. Phylogeny of the Ceratocampinae .....	33
IX. On the Phylogeny of the Sphingidae; their derivation from the Ceratocampidae.....	34
X. Origin of the Syssphingina, and also the Symbombycina from the Notodontidae.....	40
XI. Opisthenogenesis, or the development of segments, median tubercles, and markings <i>a tergo</i> .....	47
XII. The superfamily Syssphingina .....	49
XIII. Origin of the Syssphingina by both continuous and discontinuous evolution.....	50
XIV. The geographical distribution of the Ceratocampinae.....	51
XV. The fore-tibial spur or epiphysis .....	53
XVI. The nomenclature of the veins of the Lepidoptera.....	55
XVII. Classification and life histories of the Ceratocampinae.....	56



# THE BOMBYCINE MOTHS OF NORTH AMERICA.

## PART II.\*

### I. COLORATION AND PROTECTIVE ATTITUDES OF THE NOTODONTIDÆ.

#### COLORATION IN THE IMAGINES.

The species of this group are all more or less protectively colored. Their grayish, brownish hues, with yellowish or sometimes greenish markings, harmonize with the tints of the bark of the trunk or branches of trees, whether grown over with lichens or not. In their shape and size, whether at rest or flying, they closely resemble the species of Noctuidæ. They differ as a rule, however, in their slower flight, and in resting on the bark or among the leaves of trees, not nestling in grass or low herbage.

There are almost no observations yet made on the protective attitudes of notodontian moths, and the subject needs to be carefully studied. Long and close observations in the field with the aid of the camera are needed before we shall have a satisfactory body of facts, and it is to be hoped that this line of study will be taken up by lepidopterists of future generations. Many observations have doubtless been made by breeders of moths, but not published. What we have to say is mainly in the line of suggestion. The colors and attitudes of the more typical members of the family, as the species of Notodonta, Pheosia, Lophodonta, etc., when at rest, with their tufts and the consequent production of angles and points, assimilate them with the bark of trees or twigs with salient parts, buds, and other projecting points.

Those who have seen species of geometrids, Ingura, etc., at rest, with their tails curled up and their wings partly spread out, will readily understand how the species of Apatelodes, Melanopha, etc., with their tufted abdominal tips, angulated wings, and bars and spots, would tend to conceal them from the prying eyes of birds.

The species of *Melalopha* (*M. inclusa* and *strigosa*) sit with the wings folded sharply over the back, with the fore legs held straight out in front, and the tufted tail upcurved. (Monogr. Bombycine Moths, I, p. 131.)

The pale yellowish hues of *Datana* and *Nadata*, the latter with its high dorsal thoracic tuft, assimilate them with yellow and brown leaves.

Here reference might be made to Professor Poulton's statement that the shape and color of *Scoliopteryx libatrix* "forcibly suggest the appearance of a red leaf spotted with a few white bosses of fungoid growth." (Trans. Ent. Soc. London, 1887, p. 308.)

*Hyparpax aurora* may be found, like *Rhodophora florula*, to frequent pink and yellow flowers.

How the very unusual and conspicuous markings of *Edema albifrons* and of *Xerica bidentata* may mimic the dentate edges of leaves or projections of other objects will doubtless be eventually cleared up.

The ground shades and tints of the species of *Schizura* and *Heterocampa*, with their green and yellowish spots and streaks would, when the moths are resting on lichen-covered bark of their food trees, amply protect them from the observation of birds. This has been pointed out by Riley in the case of *Schizura unicornis*. "The moth always rests head downward, with the legs all drawn together and its wings folded round the body, which is stretched out at an angle

\* Part 1 of this monograph was published as Memoir 1, Volume VII, of this series of publications.

of about 45°, the dull gray coloring of the wings with the lichen-green and flesh color giving the whole such a perfect appearance to a piece of rough bark that the deception is perfect." (Riley in Packard's Forest Insects, p. 269.)

On the other hand the white ground color of the species of Cerura, with their black lines and spots, make them very conspicuous, and it remains to be seen whether these are not warning colors and whether they may not secrete a malodorous or bad-tasting fluid to render them distasteful to birds. However this may be, the secretion is not sufficiently pungent or enduring to prevent these moths from being eaten by Anthrenus larva and other museum pests.

#### ON THE LARVAL COLORATION OF NOTODONTIDÆ, AND THE ORIGIN OF SPOTS FROM LINES OR STRIPES.

The observations hitherto made on the coloration and markings of lepidopterous larvæ, with especial reference to their origin, have been those of Weismann and of Poulton on sphingid caterpillars, and of Poulton and of Schroeder on the markings of geometrid larvæ.

In preparing our monograph of the Notodontidæ we reserved for a later occasion a discussion of the origin of the stripes and spots, blotches, and discolorations which serve to protect most of the larvæ of this group from observation. What we have to offer, however, are only some facts and conclusions derived from an examination of some living larvæ and of the colored sketches illustrating our work.

Perhaps the most striking examples of the effects of lights and shadows in altering the color of the green pigment of certain parts of the body is seen in the markings of smooth-bodied larvæ which feed among pine needles. In the larvæ of Nematus and Lophyrus, the green larvæ of geometrid moths, also the larvæ of certain Noctuidæ, including the European *Pinolis piniperda*, also the species of the sphingid genus Lapara (Ellema), which habitually feed on the leaves of coniferous trees, the white and red longitudinal stripes have evidently been produced by reflections from the light and shaded portions of the leaf, while the red stripes are reflected from the red sheaths of the needles.

*Humps as means of obliteration or concealment.*—Mr. Abbott H. Thayer truly says: "As soon as patterns begin, obliteration of the wearer begins." Thus a geometrid larva holding itself out stiff like one of the twigs of its food plant, becomes lost to view. Some larvæ, he says, "appear to be extensions of leaves," and this is admirably illustrated by the remarkable caterpillar of *Verice bidentata* (Monogr. Bombycine Moths, I, Pls. XIX and XXIII). The pale green and white shades of the body, the alternating oblique bars and stripes, blend with those of the elm leaf on which it rests or feeds. This singular larva differs from all other known notodontian caterpillars, and in fact from those of any other family, in each abdominal segment from the first to the ninth, bearing a large fleshy two-toothed hump, the three largest on segments three to five. Thus, as we have stated, "the outline of the back is serrate, and perhaps mimics the serrate edge of the leaf of the elm on which it feeds;" the serrations or humps are not only of the size and shape of those of the elm leaf, but the jagged outline of each double hump strikingly resembles that of a serration of the leaf, which is two or three toothed. Besides this, the tips of the teeth of the humps are reddish brown, like those of the tips of the leaf serrations. Moreover, the oblique dark and light lines leading up to the humps, as shown in Miss Soule's excellent drawing (Pl. XIX, fig. 4), strikingly resemble the light lateral veins of the leaf and the shadows they cast.

With little or no doubt the tubercles and humps of the notodontians, of certain tree-inhabiting noctuid larvæ, as well as many butterfly larvæ, besides the geometers, are obliteration marks, and have arisen in a way difficult to explain, but evidently through a merely mechanical process, and have been the means of giving a hold on life that unarmed caterpillars do not possess.

The humped caterpillars of the notodontian subfamily Heterocampinae, especially of the genera Hyparpax and Schizura, are armed with high, often nodding, tubercles on the first, fifth, and eighth, or first and eighth, abdominal segments.

While the nutant or movable tubercles evidently so function as to frighten away other insects and thus ward off the attacks of tachina flies and ichneumons, these and the other humps

and tubercles are wonderfully adapted from their resemblance to projections of the leaf on which they rest or feed, to obliterate the form of the caterpillar.

The larvæ figured in their different developmental stages on Pls. XXIV to XXVIII of my monograph illustrate the tubercles and humps of the fully fed caterpillars, while the figures of the earlier stages show how these processes gradually develop. A striking case of deception or obliteration, dependent both on form and color, is that of *Schizura ipomoeæ*, noted by me on page 197 (Pt. I), as follows:

"Wonderfully mimics a dull blood-red portion of a leaf which had been cut partly off and become somewhat twisted, so that the larva itself would easily be mistaken for such a part of a prominent terminal leaf. The deception was perfect, as I did not myself at first see it when within 10 inches of my eyes, and on holding it before the eyes of an observing boy of 13 he could not at first recognize it as a caterpillar. The same leaf had blotches of dull red, and the flesh-red abdominal feet of the caterpillar clasped the concolorous red leafstalk."

While near the Profile House, New Hampshire, the last of September, I observed the fully grown larva of *Schizura leptinoides* on a maple. At first I entirely mistook it for an upturned tattered sere and brown edge of the leaf, being at first completely deceived, as the outlines and coloration of the creature were exactly like those of the dead and dry portion of the leaf.

This species, more than any of the others of the genus, as stated in my monograph (p. 201), bears a most striking resemblance to a portion of a dead leaf, "and several leaves were noticed with portions partly cut off and somewhat curled up, to which the caterpillars bore a striking resemblance, both in shape and color."

"The apparent aim, or rather the result of the action of the environment, has been to produce a caterpillar whose shape and color represent a sere-brown more or less twisted portion of a serrated leaf, such as that of a beech, hornbeam, and similar trees."

The caterpillar of our common *S. unicornis*, which feeds on the apple, plum, thorn, etc., mimics in shape and color the trees on which it feeds. This has often been noticed. Riley has called attention to this. Miss Emma Payne says that it furnishes a wonderful instance of mimicry. "The green segments just back of the head resemble a small portion of the green leaf, and the other parts admirably counterfeit the brown and russet tints of the dead leaf, while the form of the animal in its various postures aids the deception by its resemblance to a leaf partly alive and partly dead, the green mostly eaten and the brown torn." (Amer. Ent., ii, 341.) I have also noticed that this caterpillar feeds in a very conspicuous exposed position, but is "obliterated" or protected "by its resemblance to the twisted, partly dead, ends of some of the leaves, the oblique markings of the larva resembling the twisted dead and russet portions of the leaf."

*Schizura concinna* differs from the others of its genus in its stripes and large stout spines. These aid in rendering the creature still more alarming and repulsive to birds and less open to attack from parasitic insects. (See my Monograph, I, p. 215.)

*Period of life when the colorational features and tubercles of Schizura appear.*—As stated in my monograph (p. 207), the mimetic colorational features, "those which especially enable the larva to escape observation, appear shortly before the creature is half grown, these changes occurring at the end of the third stage, while the movable terrifying tubercle of the first abdominal segment becomes developed at the same time. When feeding on the edge of a leaf, the Schizuræ exactly imitate a portion of the fresh, green serrated edge of a leaf, including a sere-brown withered spot, the angular serrate outline of the back corresponding to the serrate outline of the edge of the leaf. And as the leaves only become spotted with sere-brown markings by the end of summer, so the single-brooded caterpillars do not in the Northern States develop so as to exhibit their protective coloration until late in the summer, i. e., by the middle and last of August (p. 207).

*The markings of the species of Heterocampa.*—In my monograph (I, p. 226) I have drawn attention to the fact in the case of these beautifully striped and spotted caterpillars, that during their ontogeny there is, after the second ecdysis, a strong tendency to a reduction in size of the tubercles, so that by the fourth stage the body becomes smooth and free from all projections

humps, and spines, and thus more noctuiform. At the same time the yellow and whitish stripes and pink blotches become indicated at an earlier stage than usual, as if the aim were to adapt the caterpillar to the hues of the ribs and parallel greenish and yellowish lines and reddish spots of the leaf on which it feeds.

A variety of *Heterocampa manteo* (Monogr., Pl. XXIX, figs. 5, 5a), with a ground color like the green of birch leaves, is beautifully colored with two subdorsal white lines, which in the third and sixth abdominal segments expand so as to contain a conspicuous deep blood-red spot on each side; there is also a lateral yellow spiracular line. As I state in the monograph (p. 228): "It is plainly derived from normal *manteo*, and is adapted for existence on the pale yellowish green underside of the birch leaf, while the deep blood-red spots are similar in color to those of the birch twigs or leafstalks."

The evolution of the red dorsal spots on *Heterocampa guttivitta* is shown on Pl. XXXI. In stage I there are no lines, the body being of a uniform reddish hue, and armed with nine pairs of horns, those of the first pair being really colossal in size, like the antlers of a stag; but after casting its skin, when the horns are all dropped, only slight vestiges of the prothoracic pair surviving, two parallel paler reddish lines arise and extend along the sides of the body. These lines widen, become diffuse and are lost or at least the lower line, just before the next ecdysis, leaving two medio-dorsal closely contiguous lines. These two lines after the second molt (stage III) become broken up into large deep blood-red patches on the thoracic and third, fourth, and seventh and eighth abdominal segments. On the prothoracic segment the two lines diverge, being forked, and this forked line persists to the end of stage IV. Already in stage III there are the indications of the three short lateral oblique lines, which are more fully developed in the fourth stage and continue to the end of larval life. They are deep red and are shaded above with white. With little doubt the dorsal red spots of the young larva of *H. manteo* (Pl. XXIX, fig. 2, 2a) arise in the same way, the spots being on the same segments, while the forked bright red thoracic line is like that of *H. guttivitta*.

In *H. binudata* also the freshly hatched larva is red, the green hue appearing after the worm has begun to eat. In this beautiful insect toward the end of larval life it is readily seen from Pl. XXXII that it is amply "obliterated" by its coloration, and stands in no need of horns, which are, rather late in life, however, discarded.

The caterpillar when at rest usually stands on the midrib on the under side of the leaf, where its green and white shades and lines well protect it from the prying eyes of insectivorous birds.

The figures of this species on Pl. XXXII well illustrate the wonderfully close resemblance in color and markings of this caterpillar to the hues of the leaf and the rust-brown and darker brown blotches on either surface of the leaves, in whatever position the larva assumes.

#### ORIGIN OF THE LINES AND SPOTS IN DATANA.

*Origin of the transverse spots of Datana major from longitudinal stripes.* The larvae of all the species of Datana, with the exception of *D. major*, are longitudinally striped. The ground color of the body in all the species is usually some shade of reddish brown or dark brown, while the stripes are reddish, yellowish, or whitish, according to the species, as may be seen by reference to Pls. X to XIV of my monograph, Part I. As is well known, these conspicuously marked caterpillars feed in an exposed manner in clusters on the apple and certain forest trees and shrubs, assuming grotesque attitudes; it is most probable, though no experiments have been made with them, that these caterpillars are distasteful to birds, since the European *Pygoera bucephala* is distasteful to lizards (Poulton). These larvae are abundant, there are numerous species, and the genus in point of numbers of individuals as well as species is a successful one.

In my work I described in some detail the differences in the markings of the larva at different stages, but failed to draw, or rather deferred to a later occasion, some conclusions as to the mode of origin of the lines, and particularly the transverse series of spots of *D. major*.

In *D. major* the larva has taken a wide departure from the style of markings of its congeners. As may be seen in Pl. XII, Part I, the young larva, up to the time when it is about half grown,

is like several of the other species, yellowish, with twin reddish longitudinal stripes. After the third molt a great change in the character of the markings takes place. The longitudinal stripes now dark or blackish brown and the yellowish or whitish stripes between them are so broken up that the result is a series of transverse lines of spots of those colors. As stated by Doctor Dyar, who has reared the insect from the egg and allowed me to publish his notes in my monograph, Pt. I (p. 114), the lines are broken by the black ground color into a series of squarish spots. "The two upper lines are broken in all the segmental incisures and broadly through the center of the segment; the third (lateral) is broken in the same manner, but less broadly in the center of the segment, while the fourth (substigmatal) is not broken in the incisure nor center of the segment, but once before the spiracle and again toward the posterior edge of the segment."

It will readily be seen that in the course of its ontogeny *Datana major* passes through the stages of coloration and markings of all the other species whose postembryonic development is known, i. e., recapitulates their phases of coloration, but finally pushes back these phases in the ontogeny and enters upon a more advanced stage, showing that it is phylogenetically the youngest of all our species of *Datana*.

How far successful the new style of markings thus obtained is over that of the older, more primitive species remains to be seen when further observations on this rather rare species shall enable us to see how well it is protected, either by its markings or its bad taste.

Further observations are needed in order to ascertain whether the process of breaking up of the longitudinal stripes into transversely arranged spots began at the hinder end of the body. The fact that the process began from above, where a greater amount of light falls upon the body, resulting in white or yellow spots on a black ground, would seem to be an exemplification of Thayer's law; that "animals are painted by nature darkest on those parts which tend to be most lighted by the sky's light."<sup>a</sup> Again he says: "While nature undeniably completes the concealment of animals by pitching their whole color gradation in a key to match their environment, the real magic lies in the gradation itself from darkest above to lightest below wherever this gradation is found."

#### PHYLOGENY OF THE SPECIES OF DATANA.

Of the twelve known species or forms of this genus only a single one appears to have undergone in the larval state a high degree of specialization of its markings, i. e., the transformation of the longitudinal stripes into transverse series of bright conspicuous whitish or yellowish spots, such as occurs in the ontogeny of *D. major*.

Since this radical change in the style of markings does not take place until after the last ecdysis, the species has evidently only recently evolved; it is phylogenetically the youngest species of the genus. We thus have in our hands a means of classifying the species of the genus, or at least of dividing them into two groups, i. e., comprising those which retain their stripes throughout larval life, and the single one (unless additional species should occur) in which the body is transversely spotted.

Since the number of species in this genus is large, and the individuals abound, the type was evidently a very successful one, and how successful the spotted species is, being so far as known rather rare, and how much it is aided by its spotted coat in evading the attacks of birds, etc., in the struggle for existence would be an interesting inquiry.

The genus *Datana* and its European ally *Pygiara* are members of a distinct subfamily, which has originated in the arctogaeic area, and as the species of *Datana* are confined to America north of southern Mexico, and within that region are unusually numerous, both in species and individuals, it is to be presumed that the original point of origin of the subfamily was on the Atlantic side of the North American continent. If this be the case the two Eurasian species of *Pygiara* may be the descendants of late Tertiary emigrants from the polar regions.

<sup>a</sup>The law which underlies protective coloration. Smithsonian Report for 1897, p. 477.

## II. THE LARVAL ARMATURE OF THE CERATOCAMPINÆ.

The armature of lepidopterous larva consists either of glandular hairs or seta, tactile hairs, and defensive spines, and in function are either glandular or simply tactile, or both functions combined, or are defensive, the base of the spines of larva of the group *Cochliopodidae* being glandular and secreting an active poison. The seta are secreted by unicellular dermal glands.

The base of the seta is strengthened by the deposition of chitin or parenchyma so as to form a pediment or support of the seta, and as a rule the size of the wart or tubercle thus formed is correlated with that of the seta or spine arising from it.

*Change of function in the armature.*—While the primitive function of the hairs, judging from the fact that they appear to have arisen in freshly hatched larva of the more primitive groups of Lepidoptera, though present in the first stage of butterfly larva and in *Notodontidae*; they also at the same time served as tactile or sense-hairs. Then from being simply tactile they, by use or as the result of external stimuli resulting from the attacks of other insects, etc., became so strengthened, chitinized, and spiny as to render the animal unpalatable or inedible, as nearly if not all hairy caterpillars are known to be.

A final step was the secretion of an acrid pungent poison at the base of the spine, as notably in the case of the *Megalopygidae*, *Liparidae*, *Hemileucidae*, and *Saturniidae*.<sup>a</sup>

The glandular hairs occur on the larva of *Pterophoridae* (Dimmock). I have observed them in the first larval stages of *Platypterycidae* and *Notodontidae*, as well as certain *Sphingidae* (*Deidamia insculpta* and *Ampelophaga myron*); also in the *Saturniidae* (Attacinae); also in *Ceratosis tricolor*. According to Scudder, in his work on the Butterflies of the Eastern United States, they occur on the freshly hatched larva of the *Nymphalidae*, *Lycenidae*, and certain *Papilionidae* (*Papilio cresphontes*), *Pierinae*, and *Hesperiidae*.<sup>b</sup>

*Origin of the tubercles or tubercular base of the bristle or seta.*—Not only in lepidopterous larva, but also in those of other orders, especially certain larval *Coleoptera* and *Panorpidae*, do the setae arise from a swollen, fleshy, or chitinous base forming a wart or tubercle. When giving off a hair or bristle such tubercles are referred to as setiferous. Theoretically the swollen base of the hair (see Part I of this Monograph, Pl. XXVI, fig. 1b) is apparently due to the motion of the long slender hair in touching objects, as the caterpillar creeps among the leaves of its food plant. Such motions and stimuli lead to the aggregation of tissue around the base of the seta, serving to support it. The simple primary seta with its conical tubercle may lose its functions and atrophy so as to leave only the tubercle, which may be soft, fleshy, as in certain *Notodontidae* in which they are nutent, and thus fitted by their slight movements to ward off or at least deter parasitic insects from ovipositing on them. On the other hand, the tubercle may, as in the *Ceratocampidae*, become converted into a purely defensive horn-like spine, with branches like a deer's horn, as in *Eacles* and *Citheronia*, etc. The horn-like spines on the prothoracic segment of *Heterocampa* are remarkable from their apparently sporadic occurrence in a group which are as a rule not provided with spinous protections.

*Arrangement of the setiferous tubercles in Lepidoptera.*—While the larva of certain *Coleoptera*, *Diptera*, *Panorpidae*, etc., are hairy and, as in *Panorpidae*, arise from a swollen conical base, i. e., a tubercle, their special arrangement in the Lepidoptera is, so far as known, diagnostic of the order.

In the *Panorpidae*, which, in some important respects, are allied to what may have been the ancestral stock of the Lepidoptera, the seta, judging by Brauer's figures of the first and final stages

<sup>a</sup> For notes on the armature of various families of moths see Proc. Amer. Phil. Soc. xxxi, 1893, pp. 83, 139.

<sup>b</sup> See my Notes on some points in the external structure and phylogeny of lepidopterous larva. Proc. Boston Soc. Nat. Hist., May, 1900, pp. 83-114.

of *Panopaea communis*, form a series passing around the segment a little in front of its middle. There are no setæ corresponding in position to seta *ii* of lepidopterous larvae: that is, there is no posterior pair of dorsal setæ, but the series of eight or ten setiferous tubercles to a segment form a line passing on the side of the segment considerably behind the spiracle. In the Trichoptera, as Dyar has observed, there are no setiferous tubercles.

In the larvae of the more primitive groups of Lepidoptera, and in stage I of the more specialized families, I have always observed that, looking at the animal from above, there are two pairs of setiferous tubercles, or four in all, arranged in a trapezoid, the tubercles of the hinder pair being wider apart than those of the anterior pair. This disposition in a primitive, generalized form is seen in fig. 7, p. 63, of my monograph of Notodontidae, representing the larva of *Adela viridella*, also fig. 9. This arrangement of the four dorsal setiferous tubercles is common to all the more generalized lepidopterous families—as the families comprising the Tineina, the Hepialidae (p. 72, 73, figs. 31, 32), the Pyralidae, Noctuidae, etc. If we refer to these setiferous tubercles as arranged in longitudinal series, such series may be designated as the dorsal, subdorsal, supra and infraspiracular series, though this classification does not well bring out the varying position of the posterior dorsal pair.

A more exact designation is that proposed by Doctor Dyar in 1894, who showed that there are two types of arrangement. "The first, which is by far the more generalized, consists (considering only the abdominal segments) of five tubercles above the spiracle on each side, three in a transverse row about the middle of the segment and two behind; below the spiracle are two oblique rows, containing, respectively, two and four tubercles. This type is found in Hepialus, and is probably typical of the larvae of the moths in Professor Comstock's first suborder, the Jugatae."<sup>a</sup>

"The second type contains two dissimilar lines of modification of the first type: but, as they agree in number of tubercles and in other characters, I will consider them together. The fundamental arrangement of the tubercles is as follows: On each side above the spiracle three tubercles; below, or behind the spiracle and above the base of the leg, three more; on the base of the leg, three (or four) on the outside and one on the inside near the midventral line. These I propose to designate thus, counting from the dorsal line down the side: Tubercles *i*, *ii*, *iii*, above the spiracle, *iv*, *v*, *vi* below it, the group of three on the outside of the leg as *vii*, and the single one on the inside of the leg as *viii*. Tubercles *vii* and *viii* are present also on the legless abdominal segments (viz., segments 1, 2, 7, 8, and 9 of the abdomen) in the corresponding position."

Doctor Dyar has skillfully used these setæ or setiferous tubercles in classifying the families of Lepidoptera, especially in separating the more generalized from the more specialized; yet in some cases they hardly seem the best guide. It should be borne in mind that any single character or set of characters do not prove in all cases reliable, since they shift or disappear in specialized types and other characters are substituted and become prominent by being more useful and adaptive, and, as we shall see, the tubercles *ii* are the most variable in position and development of any on a segment during the ontogeny of a species or group, and are thus important in working out the phylogeny of the Lepidoptera or some special group.

The arrangement of the tubercles *i-viii* on the trunk segment of a syssphingine moth, is illustrated by Fig. 1. It will be observed that tubercle *v* is below, while in the Sphingidae it is situated directly in front, of the spiracle.

*Presence or absence of dorsal tubercles ii.*—The presence, reduction, or the atrophy of this pair of tubercles in the course of the ontogeny has an intimate bearing on the phylogeny of the subfamily under discussion.

In the first stages of *Adelocampa bicolor* this pair of dorsal tubercles are present (Pl. XLV, fig. 2, *ii*), the four dorsal tubercles being arranged in a trapezoid on abdominal segments 1 to 7, and in a modified form on segments 8 and 9. It persists through stages II to III. Their presence in the fourth and final stages is more doubtful, since the surface of the body is scattered over with

<sup>a</sup> "I have not had Micropteryx for examination."

minute secondary setiferous tubercles, and it is difficult to distinguish the primary ones, whose growth has become retarded or stationary, from the latter set, since they are so reduced in size.

To enter more into details, while the tubercles of the anterior dorsal pair (fig. 1) in stage I are already large and much specialized, the integument crenulated or wrinkled, the seta finely spinulated, while the long tubercle sends off a posterior tine or spur near the base; on the other hand, the tubercles of the hinder pair ( $\text{ii}$ ) are minute in comparison and primitive in shape, the tubercle itself a simple cone and the seta simple hair-like. Both sets of tubercles ( $\text{i}$  and  $\text{ii}$ ) occur on abdominal segments 8 and 9, the caudal horn on 8 being a highly modified tubercle  $\text{i}$ . The same relations exist in stages II, III (figs. 2, 3,  $\text{ii}$ ). In stages IV and V, or the last instar, tubercles  $\text{ii}$  are difficult to distinguish from the secondary ones, which are rather thickly crowded over the dorsal surface; they can be distinguished on abdominal segment 8 directly behind and near the base of the caudal horn. It may be observed that all the thoracic and abdominal horns are in Adelocephala hypertrophied tubercles  $\text{i}$ , and this will apply to the Ceratocampidae in general.

In *Syssphinx molina*, stage I, tubercles  $\text{ii}$  are wanting on abdominal segments 1 to 7, though present on segment 8 behind the caudal horn. This atrophy of  $\text{ii}$  at once clearly indicates that

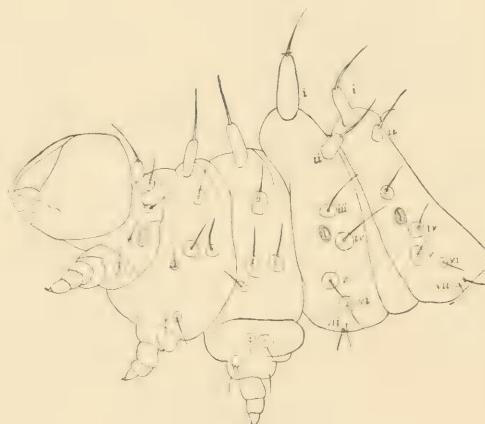


FIG. 1.—Head and first five trunk-segments of *Schizura concinna*, showing the arrangement of tubercles  $\text{i}$ - $\text{vii}$ .

this genus is a later, less primitive form than Adelocephala, a view corroborated by other characters.

In *Eacles imperialis*, which, generally speaking, has evidently almost directly descended from Adelocephala, the tubercles  $\text{ii}$  are absent in all the stages on abdominal segments 1 to 7. On segment 8 the tubercles  $\text{ii}$  are situated next to the caudal horn and are of good size in stages I, II, and all the later stages, being about as large as tubercle  $\text{iii}$  on the side of the segment.

In *Citheronia regalis* there are no tubercles  $\text{ii}$  on abdominal segments 1 to 7, but they are in stages I to V on segment 8. In stage I they are about one-half as large as the caudal horn itself. In stages II and III (Pl. LIV) they are large and branched, while in the last two stages they become reduced, until in the final stage they are about as long as the caudal horn is thick at its base.

These tubercles ( $\text{ii}$ ) are present on the eighth abdominal segment in *C. separalis* in all stages; in *C. splendens*, stages IV and V (Pl. LV), and in the last stage of *C. laeta* (Pl. LV).

The species of Anisota form a side branch situated somewhat off the main evolutionary track, having undergone a greater reduction of tubercles in the larval state and of the maxilla in the imago than any of the other Ceratocampinae. Yet in the first larval stage of each of the four

species the trapezoid made by tubercles *i* and *ii* is present on abdominal segments 1 to 8. In *A. stigma* (Pl. LI) in stage III *ii* have disappeared on segments 1 to 7, and in this stage and later stages in all the species these tubercles (*ii*) seem to have become atrophied, but retained on the eighth abdominal segment. In *A. virginicensis* of the last stage tubercles *ii* on this segment are nearly obsolete and white, like the neighboring secondary tubercles in the specimens examined, but this may be an individual variation, as in all the tubercles there is some difference in development. In a full-grown larva of *A. stigma* the tubercles *ii* on this segment are larger than in *A. virginicensis* and black or chitinized and pigmented. In *A. rubricunda* of the last stage the tubercles *ii* are fairly distinct, but not pigmented, while in *A. senatoria* they are larger than in the other species and pigmented dark reddish-brown like the other dorsal and lateral spines. Why this pair of tubercles are retained on this segment and disappear on those in front is not easy to explain, unless it be that they are protected by the overhanging caudal horn, for they are longest and best developed in Citheronia, which has the largest caudal horn of any of the subfamily.

The lower tubercles, supra- and infra-spiracular, are in the same line as the spiracles *iii*, being directly above the spiracle and in a line with tubercle *i*, as in the family generally and the Saturniidae, as already observed by Dyar.

*Absence of tubercle i on the ninth abdominal segment.*—In referring to the unpaired dorsal tubercle on the ninth abdominal segment Doctor Dyar<sup>a</sup> states that it corresponds to *ii*, "as tubercle *i* is not present on the ninth segment." In the Ceratocampinae there is but a single pair of dorsal tubercles on this segment, fused in the later stages; since they are situated near the hinder edge of the segment, I take it they are tubercles *ii*, but otherwise I do not now see how they can be distinguished from tubercle *i*.

The history of the compound or fused horn or tubercle on this segment will be seen by reference to Pls. XLV and XLVI of *Adelocephala bicolor*.

In Anisota the double nature of this tubercle is plainly seen in the first stage of all the species. In *A. virginicensis* (Pl. L, *ii*) the two setiferous tubercles *ii* are seen to arise from a common swollen base; in stage III the tubercle is slightly but distinctly forked, and the paired nature of the spine is seen in the full-fed larva in the pair of bristles arising from the end of the tubercles (Pl. LII, figs. 1b, 1c) not showing any terminal division. In *A. stigma* (Pl. LII, fig. 3) the separate swollen bases of the setae in stage I are seen to arise from a common large tubercle; in stage II (fig. 3a) the setae are shorter but separate at base; while after the second molt the tubercle becomes solid, pigmented, as in *A. virginicensis*. In *A. senatoria*, stage I (Pl. LIII, fig. 1), there are, as in all the other species, no traces of tubercle *i* and the double tubercle *ii* arises as in the other species, but in stage II (fig. 1a, *ii*), besides the primitive setae, which are wide apart at base, there have arisen two secondary minute setae (showing that this species is younger than *virginicensis* and *stigma*); in stage III (fig. 1b, *ii*) the tubercle is much less advanced than in the other two species mentioned, since the tubercular base of each seta is still separate from its fellow, the two tubercles arising from a common base; from an oblique point of view the tubercle is seen to be more deeply forked than in the other two species mentioned (fig. 1b, *ii a*). In *A. rubricunda*, stage I (fig. 2, *ii*), the tubercle is as in *A. senatoria*. In stage III the tubercle seen vertically and from behind or obliquely (fig. 2b, *a*) to be deeply forked, and bearing at least 8 or 10 fine secondary setiferous tubercles, which suggest that this species is the most specialized and therefore recent species of any of the others, this view being corroborated by the other features of its armature and coloration. In the final stage the tubercle is slightly forked.

In *Syssphinx*, *Eacles*, and *Citheronia*, tubercle *i* appears to be absent in stage I and throughout larval life. The fused tubercles *ii* in *Adelocephala bicolor* is in the last stage much reduced, is simple, conical, not pigmented, but whitish, though showing the scars of two small setae.

In *Syssphinx molina*, judging from Burmeister's figure, it probably is much as in *Adelocephala bicolor*, reduced and scarcely distinguishable except by position from the secondary tubercles. It appears to be a little more prominent in *A. wardi*, and still more so in *A. argyraacantha*.

In *Eaeles imperialis*, stage I (Pl. XLVII, fig. 2, *ii*), the midtubercle is large, highly developed, each *ii* being subdivided or two-headed. In stage III it becomes smaller in proportion, a little longer than the diameter of the caudal horn at its base, and four-headed; it becomes shorter in stage IV and after the last molt is still more reduced and is forked, but no higher than broad.

In *Citheronia regalis* (Pl. LIV) this spine is, in accordance with the rest of the armature, much more developed than in the other genera. It is in stages I, II, III about half the thickness and length of the caudal horn, repeating its shape and spinulation, while in stages IV and V it is about a third as long.

In *C. splendens*, in stages IV and last, it is about two-thirds as long as the caudal horn, while in the last stage of *C. sepulralis* it is much shorter, only about one-fourth as long as the caudal horn.

*The thoracic armature.*—We will begin with Adelocephala, whose mature larva is throughout the body the most spiny, the abdominal segments between the first and the eighth bearing the caudal horn, being armed with large, and in certain species conspicuously colored, spines or horns. The group is remarkable for the enormous thoracic and caudal horns in the earliest stages.

In stage I of *A. bicolor* (Pls. XLV and XLVI) and of *Syssphinx molina* (Pl. XLVII), the remarkable features are the enormously developed second and third thoracic tubercles or horns, which are three times as long as the caudal horn. While the specific and generic differences are given in detail under the special description of each life history, we may here give a comparative account of the form and history of the thoracic spines in the Ceratocampinae.

The prothoracic segment in the two genera already named is usually provided with setiferous tubercles of even less than normal size, the dorsal ones no larger than the lateral ones, there being six on each side of the segment. But in the undetermined mature Brazilian larva (Pl. III, fig. 1, and Pl. XLIX, fig. 4), they may be found in stage I when discovered to be long and well developed; they are distinct, fairly long prothoracic dorsal spines.

In Eaeles and Citheronia, however, there is a great change; those of the dorsal pair being enormously developed, and ending in a fork or two twin setiferous tubercles, repeating the two forms of those on the two hinder thoracic segments. In Eaeles the dorsal spines or horns are between one-fourth and one-third as long as those behind, have two to three secondary tubercles, and end in two long diverging setiferous branches or tubercles about a third as long as the entire horn. This form is repeated in the subdorsal horn, which is of the same general shape, but with a shorter main shaft.

Of the horns behind, those of the mesothoracic segment are a little longer than the metathoracic ones. In Eaeles the tubercles of the supraspiracular series are alike on each three segments in being primarily two-headed, but with such large secondary setiferous tubercles as to make them appear five-headed. The infraspiracular spine on the first thoracic segment is very large, three-headed, while the one below is double headed. There are in all five tubercles on each side of this segment. It is to be observed that in Eaeles and Citheronia there is, contrary to Adelocephala and Syssphinx, a close similarity in shape and size between the caudal horn and the thoracic horns.

In *Citheronia regalis*, the dorsal prothoracic horns are still more similar to those behind, being nearly as long, and of identical shape and similarly spinulated. There is a marked difference in the development of the subdorsal horns of Citheronia, these being very much longer than in Eaeles, and only slightly differing in the shape of the bulbous end. The greater specialization of the swollen end of all the eight horns as well as of the caudal horn in Citheronia is of interest. The bulb is shaped like a chestnut, full, thick, forming the common base of the two diverging tubercles, which bear specialized setae in the form of cylindrical straight rods, blunt at the end; a seta of very characteristic shape. This style of specialized seta also occurs in the thoracic horns of Adelocephala and Syssphinx, though in the caudal horn it does not appear, the seta being of their primitive shape.

In Adelocephala, after the first molt (Pl. XLV, fig. 3), thoracic horns differ in the reduction of the bulbs, which lose their swollen shape, becoming simply forked, and the rods becoming mere setæ. In the third and later stages there is a further reduction of the two terminal spines, the horns ending in a double point, with little significance, while the horns themselves become shorter. On the other hand, a new and striking feature comes into prominence, *i. e.*, the silvery color associated with pink of the larger tubercles on abdominal segments two, four, and six (Pl. XLIX, fig. 2b), as if the welfare of the species depended on this new colorational feature. Just how this is to be explained depends on further special observation of the living caterpillar amid its surroundings of leaves and spines.

In Eacles, stage II, a profound change takes place in the armature, the reduction of the size of the spines being marked. From the prothoracic to the tenth abdominal segment they are cut down, reduced. New influences have begun to be exerted, and the formidable set of complex spines, inherited from some extinct ancestor, no longer of use, become discarded, and a new kind of protection arises, these perhaps being the hairs so peculiar to this genus. In the third stage the thoracic spines are as long as the body is thick, and taper at the end, which is forked; in stage IV the horns are now considerably shortened, not so long as the body is thick, while those on the prothoracic segment are scarcely higher than broad. After the final molt the prothoracic spines (Pl. XLVIII, figs. 3, 4) are reduced to broad, low, flattened rough tubercles; those of the two following segments are reduced to short, stout, conical tubercles, about half as long as those in the fourth stage, and they are now shorter than in any other genus excepting *Syssphinx*.

In the second stage of *C. regalis* the bulb of all the horns have become modified into two simple branching spines, each ending in a simple seta (Pl. LIV). The larva in this stage bears a forest of twelve spinulated, long, slender spines, the longer ones equaling half the length of the body, while at the end of the body is a less dense forest or thicket of repellent branching thorny spines.

In the third stage the horns are still slender, and the spinules, being large and long, they appear to be much branched. In the fourth stage they have become three times as stout as before and of the same thickness and length, but a little longer in proportion than in the last stage. Their effect is in the two last stages heightened by the black thoracic and the abdominal oblique bands.

It still remains to be seen whether these spines secrete at their base a poison; and it is to be hoped that close and repeated observations will be made on the larvae while feeding to see how far they are protected by their armature and dark conspicuous stripes from the observations of birds, etc.

It should be noted that while *C. regalis* has the longest spines of any species of the genus, in *C. sepulcralis* they are shorter, while in the Brazilian *C. penelope* they are scarcely longer than in *Eacles imperialis*.

*The hairs of Eacles vs. the reduction in the spines.*—The bodies of all the Ceratocampinae except Eacles are destitute of hairs. In Eacles the long irregular hairs are a generic feature. They first appear in stage II, but in stage IV these long white hairs are frequently as long or a little longer than the body is thick. They are longer in the penultimate than the last stage, and form a more dense clothing. Now, it is well known that birds and ichneumon flies of various kinds avoid hairy caterpillars, and the question arises whether the hairs of Eacles in its last stage do not to some extent protect the creature from its natural enemies, and whether, since it is thus protected, the spines have undergone reduction from being no longer useful in defense. On the other hand, it is only fair to state that *Citheronia penelope*, with horns scarcely longer than those of Eacles, is destitute of long hairs, though the vestigial dorsal tubercles of the abdominal segments are represented by Burmeister as giving rise each to three or four short setæ.

*The dorsal spines of Anisota.*—In this genus the armature is so reduced that there is but a single pair of horns on a single segment, the second thoracic, and this reduction is associated in the moths with the atrophy of the maxillæ. In each of the four species whose ontogeny is

known the larva is hatched with this pair of horns alone, and it is significant that they are situated on the most exposed part of the body.

In stage I the dorsal spines are throughout longest in *A. virginensis* (those of the third thoracic segment largest in this species), and in this respect this species is the most primitive or nearest its supposed Adelocephala ancestor; the dorsal spines are longest in *A. stigma*, are shorter in *A. senatoria*, and much the shortest in *A. rubicunda*.

It is noteworthy that in the full-fed larva the dorsal horns of the second thoracic segment are longest in *A. virginensis*, shorter in *A. senatoria*, and shortest in *A. rubicunda*.

The question arises as to the probable cause of the reduction in all the spines in this genus. This may perhaps be answered by the fact that they do not need a defensive armature, owing to the style of coloration, the body being striped, like so many unarmed caterpillars, especially Noctuidae, etc. Moreover, the eggs are laid in large patches of over 200, the young larvae live gregariously on the under side of leaves of the oak, maple, etc., which bear no spines, while this gregarious habit in all but *A. rubicunda* is maintained throughout larval life, as they, especially *A. senatoria*, are seen to be crowded together in clusters on the partly defoliated twigs of the trees, somewhat after the manner of caterpillars of Datana.

*The suranal plate and its modifications.*—This is the reduced tenth abdominal segment, and is flattened triangular, rather large, usually ending in a fork.

In its perhaps most generalized form, that of *Adelocephala bicolor*, the suranal plate in stage I is armed with three well-developed setiferous tubercles, the tubercles themselves conical but higher than thick at the base, and bearing a long slender seta. The plate is forked at the end, the two terminal tubercles giving it a forked appearance; there is also a pair of setiferous tubercles similar in size and shape to the others, each one situated a little way in from the edge and behind the middle. There are no secondary setiferous tubercles. This description will also apply to *Syssphinx* in its first stage.

In the succeeding stage (II) and all the later stages the end of the plate is distinctly forked and the surface of the plate is rough, with five secondary setiferous tubercles, while the primary ones are but little larger than the secondary ones and merely hold their own in size; on the base of the two terminal tubercles forming the fork are several secondary setiferous tubercles.

In the last stage the seta are much reduced in length, nearly atrophied in many cases, and the surface of the plate is rather evenly granulated.

In *Anisota rubicunda* (Pls. LII, LIII) the suranal plate is rather short, rounded at the end, having lost the salient features of that of *Adelocephala*. The setiferous tubercles in stage I are minute, though the bristles themselves are long, hair-like. The typical number is five on each side, three marginal ones, one situated within, beyond the middle of the plate, and the pair of terminal ones. After the first molt the pair of terminal tubercles are much larger than before, giving the plate a forked appearance. In the last stage the primary tubercles are large, distinct, and black-pigmented.

In stage I of *A. rubicunda* and *senatoria* the plate is simplest; in *A. virginensis* and *stigma* it is more specialized and somewhat pigmented. In the second to the final stages, however, of *A. senatoria* the plate is more stoutly spinose than in any other species, the lateral and two terminal spines or tubercles being solid, conical, and pigmented brown black (fig. 2).

In *Eacles imperialis* the armature of the suranal plate is very formidable in the two first stages (Pls. XLVIII, figs. 1, 2), especially before the first molt. The first tubercle, i. e., that nearest the ninth segment, on each side is very large, four-headed, and as long as the entire plate. In the second stage, the tubercle spines are reduced in size but retain the same structure, the seta remaining; but after the second molt the great basal spines become reduced to low, flattened, broad, bubbly vestigial tubercles, with secondary tubercles. The plate is black in the last stage, with the edges yellow, while the granulations, or low stout conical tubercles, are coarse and render the surface of the plate rough.

In *Citheronia regalis* the armature of the suranal plate is similar to that of *Eacles*, on the same plan, but the tubercles and their spinules are much longer and slenderer, as seen in Pl. LIV, figs.

1, 3. (*sI*). In stage III, the proportion between the spines is still the same; now, small secondary setiferous tubercles have arisen. In stage V (fig. 6) the two lateral tubercles *sI* are reduced to low flattened four-headed ones, and the plate is well rounded at the end; the two terminal black tubercles are minute, while the surface of the plate is without secondary tubercles, not being coarsely granulated as it is in *Eacles*. In *C. splendens* (Pl. LV, fig. 1*a*, 1*b*) the armature is more excessively developed than in *C. regalis* or any species of the genus, and the surface of the plate is covered with transverse rows of secondary tubercles, the two terminal tubercles being distinct. In *C. sepiulalis* the armature of the surface is intermediate between the two species named (figs. 4*a*, 4*b*), while in *C. laevicollis* the plate is nearly smooth, with small tubercles *sI*, being much as in *C. regalis*. On the other hand, in *C. phoronea*, judging by Burmeister's figure, tubercles *sI* are much longer, but the surface is merely rugose as in *C. regalis*.

In conclusion, the suranal plate and its armature coincide or are congruent with the other larval characters, so that if found fossil they would afford a fair basis for identification and classification.

### III. THE CAUDAL HORN OF THE CERATOCAMPIDÆ.

The larvae of Ceratocampidæ and Saturniidæ, as well as a few other lepidopterous larvae of other groups, and more especially the Sphingidæ, are characterized by possessing the so-called "caudal horn." This modified tubercle is now known to be the result of the fusion either before birth, or before the first ecdysis, of the dorsal tubercles *i* of the two anterior tubercles of the eighth abdominal segment. We have designated this double tubercle as the "eighth uromeral tubercle;" the term uromere being applied to any one of the abdominal segments. We will first describe it in the group Ceratocampinae, and then discuss its mode of origin and occurrence, as well as its phylogenetic significance, in other groups.

*Caudal horn of Ceratocampinae*.—In the species of the most generalized genus, Adelocephala, the caudal horn is very large and prominent, as long as any of the thoracic horns in *A. bicolor*, twice as thick, and considerably stouter; it is roughly tuberculated with secondary setiferous tubercles; and at the tip has lost the bifid nature of the first two stages, ending in a single tubercle which does not bear a terminal seta.

We will now trace its history from stage I up to the last. The great thick club-like slightly curved horn ends in two primary tubercles, each bearing a stiff seta about as long as these tubercles (Pl. XLV, fig. 1). In stage II (fig. 3), the caudal horn is slenderer than before (in the specimen figured it had become flattened down and attached firmly along the back).

In the third and fourth stages the bifid nature is lost, and the horn ends in a single bristleless tubercle as in the last stage, the terminal or primary tubercle being but little larger than the secondary ones which render the horn so rough and coarsely spinose.

In the full-grown larva of *A. wardi* and *argyreantha*, as figured by Burmeister, the caudal horn is slightly longer and twice as thick as either of the thoracic ones.

In stage I of *Syssphinx molina* the caudal horn, like that of Adelocephala, is entirely unlike in shape and length the thoracic horns, being much shorter and nearly twice as thick (PL XLVII). In *Syssphinx* the swollen, squarish end bears on each side a short rounded tubercle, each giving rise to a long bristle, the main tubercle showing no signs of its double origin.

In *Eacles imperialis* the caudal horn is nearly as large as any of the thoracic ones of the same shape, the end being deeply divided, with no definite line of division between the two terminal tubercles and the main shaft of the "horn;" the setae are a little longer than the forks or branches. After the first molt the proportions are the same, all the horns being reduced in size. In stage III the horn is still long and slender, but only about one-half as long as the longest thoracic horns.

After the third ecdysis there is a decided reduction in size of the caudal horn, which, though still quite large and prominent, is only about half as long and large as the largest thoracic horns. In the fully grown larva, where the process of reduction has affected all the armature, especially the dorsal spines, the caudal horn is reduced to a conical spinose tubercle but little higher than broad, though still only about half as high as the larger thoracic ones; and now the somewhat dense secondary hairs rise far above the dorsal spines.

In *Citheronia regalis*, stage I (Pl. LIV), the relations are much as in Eacles. The caudal spine is a nearly exact repetition of the twelve thoracic ones, ending in a similar bulbous body formed by the fusion at their bases of the two terminal tubercles, each division or fork ending in a thick blunt rod.

In stage II the caudal horn again repeats the now somewhat modified shape of the horns on the thoracic segments (fig. 1), ending in two unequal spines.

In stage III the caudal horn is of the same proportionate shape and height (fig. 3).

In the last stage the caudal horn is high and prominent, being as large as the subdorsal thoracic horn, spinose, and distinctly forked at the end (fig. 6).

In *C. splendens* (Pl. LV, fig. 1a, 1b i) the horn is much shorter, but still bifid at the end; in *C. septentrionalis* (fig. 4a, 4b) it is much longer, but still ends in two minute tubercles; in *C. laevicornis* (fig. 2, h) it is rather shorter and slenderer than in the other species mentioned.

Anisota differs remarkably from the other genera of its group in having no caudal horn on the eighth abdominal segment, the primary setiferous tubercles / not being crowded and fused into one after the first molt, the characteristics of stage I being retained throughout larval life, the four primary dorsal setiferous tubercles being arranged in a trapezoid. It should be noticed that the eighth abdominal segment is not any narrower than the seventh, while the ninth is much narrower, the body rather suddenly narrowing to the end of the suranal plate. Whether this width of the eighth segment has caused crowding and the fusion of the tubercles / is a matter worth considering, though in Adelocephala and *C. regalis* the eighth segment appears to be as wide as the seventh. Yet it remains a fact that in Anisota there is no fusion of tubercles /, no median dorsal horn, whereas there is a fusion on the succeeding segment and a resulting median tubercle. Its history is given on page 13 and the reader is referred to Pls. L-LIII, which illustrate the development of this ninth uromeral caudal or median horn in Anisota.

Here the question arises whether the lack of fusion of tubercles / on the eighth uromere is due to inheritance from some notodontian ancestor, to reversion, or is simply the result of disease, resulting in reduction and partial atrophy. When we take into account the close relationship between the moths of Anisota and Adelocephala, the incongruity between the larval stages in respect to the armature of the end of the body seems remarkable.

It is to be observed that the ninth uromeral tubercle or median horn in the final stage shows its double origin in being bifid at the end like that on the caudal horn of the eighth segment in other genera than Anisota.

This ninth uromeral tubercle is well developed in all stages in Eacles and *Citheronia* Pl. LIV (fig. 6), but exists in a much reduced condition in Adelocephala and *Syssphinx* of the first to the final stage.

*The caudal horn in the Notodontidae.*—In only two groups or families is the caudal horn a nearly persistent characteristic common to nearly every genus of these extensive groups—I refer to the Ceratocampidae and Sphingidae—while the more specialized Hemileucidae and Saturiniidae have a similar double median tubercle, which retains its rounded or clavate form. Elsewhere the fusion of the tubercles / on the eighth uromere is a sport, aberration, or, better, a mutation, which has become fixed by heredity. Such is the caudal horn of *Bombyx mori*, of *Endromis versicolora*, the earlier stages of Brahmaeidae, and of certain Notodontidae.

Its appearance in this group we will first discuss, since their stages of evolution have been examined and illustrated in my monograph of this family. In this group the larvae before the first molt have the primitive arrangement of the four dorsal setiferous tubercles (i, ii) arranged in a trapezoid, as seen in the freshly hatched larva of *Lophodonta*, *Pheosia*, *Dasylophia*, *Hyparpax*, *Schizura*, and *Heterocampa*. A caudal horn or tubercle arises in the ontogeny of the larva in four genera, i. e., *Pheosia*, *Dasylophia*, *Hyparpax*, and *Schizura*.

The tubercle is most characteristic in *Pheosia*, being like that of *Sphinges*, *Bombyx mori*, and ceratocampids, except that it is smooth and not solid and tuberculated. If the reader will turn to Pl. XX of my monograph of the Notodontidae and consult the description of the early stages he will obtain an idea of the mode of origin of the so-called horn. In stage I the arrangement of the dorsal and subdorsal setiferous tubercles is plainly drawn. The pair of tubercles / on the eighth abdominal segment are, at the birth of the larva, crowded together, their bases forming a

common foundation or wart-like tubercle. To quote from my account: "On the eighth segment is a single central dorsal, black, oval, moderately prominent wart, which is twice as large as the largest on the ninth segment; it is transverse, bearing a bristle at each end, thus having plainly originated from what was once two separate warts." At the end of this stage, before the first molt it becomes a double, large black tubercle, still ending in a pair of setae; after molting (stage II) it is "now well developed, high, conical, and fleshy, slightly inclined backward, dark at tip, and still bearing two bristles, though the dark chitinous spine is obsolete; the horn-like tubercle is half as high as the segment is thick." In the next stage it is nearly as long as the eighth segment is thick vertically. "The horn is slightly retractile in this stage, and the base is movable, being capable of withdrawal and extension and is distinctly nutant, the apex sometimes hanging over backward." In the fourth stage the horn becomes larger, higher, and more acute than before: "it is freely elevated or allowed to fall over backward, is soft and flexible, but very slightly retractile, and bears a few scattered, fine bristles." In the final stage the horn is high, stiff, not granulated, but somewhat annulated. The horn is more like that of a sphingid than a ceratocampid, in not forming a solid spine, though this is not invariably the case in the Ceratocampidae.

In the allied genus *Dasylophia* the larva is hatched with the two tubercles *i* on the eighth abdominal segment still separate, and thus represents an earlier stage in the ontogeny than in *Pheosia*. In stage I this pair of tubercles each end in a bristle; in stage II and later stadia the tubercles are fused to form a low, flattened tubercle, the seta being lost.

In *Hypopyra aurora* and the species of *Schizura*, whose segments are nearly all dorsally humped, each side ending in a seta, the fleshy tubercles on the eighth abdominal segment are as large or nearly as large as those on the first abdominal segment. In *S. leptinoides* the fusion of what corresponds to the caudal horn is seen in Pl. XXVI, fig. 1, tubercles *ii* having apparently become atrophied. The cause of the fusion of these tubercles, whether on the first or eighth abdominal segment, is obscure, but probably it is a mechanical one.

In some respects the most specialized genus is *Heterocampa*, and in two of the species whose ontogeny is known, i. e., *H. obliqua* and *H. guttiritta*, certain segments are armed with a pair of dorsal chitinized solid spines or horns. Those on the eighth abdominal segment are well developed, being long, erect, and bearing a few secondary spines. (See Pls. XXX and XXXI of my Monograph of the Notodontidae, also fig. 85.) Their bases are, however, wide apart and there are no signs of a tendency to fusion. They disappear at the first molt, and are probably either defensive structures inherited from some earlier form, or have arisen with comparative rapidity, a sport or mutation due to stimuli from without. The ninth abdominal segment in these two species is well developed, but smaller.

These caudal horns do not appear in the first stage of *H. binndata*, *H. manteo*, *H. unicolor*, or *H. astarte*, which are thus proved to be more recently evolved. In the tailed forms, such as *Heterocampa unicolor*, *Macrurocampa* and *Cerura*, it is possible that the growth energy expended in the production of the armature has been transferred to a process of hypertrophy of the anal legs.

Reference should also be made to the species of Notodontidae, *Symmerista*, etc., which bear a hump or broad, low tubercle on the eighth abdominal segment, apparently resulting from the fusion of the primitive setiferous tubercle.

*The caudal horn of the Bombycidae.*—In the majority of the species of this interesting group, represented by *Bombyx mori*, there is a well developed caudal horn.

In stage I the larva is similar to a young *Malacosoma* (*Clisiocampa*), having the fine hairs arising in tufts from small warts, but already the two warts on the eighth abdominal segment have united into one.

On examining a series of larvae in the fourth stage the caudal horn is seen to be soft, fleshy, thick at the base, and rather densely clothed with comparatively coarse setae; it rather suddenly contracts toward the end, which is somewhat acute, pointed, the tip dark chitinized, and bearing no signs of its originally double origin; the slender end of the horn bears no hairs and is very finely granulated.

In the final stage the horn shows some reduction, being shorter than in the previous stage. There is no tendency to fusion of the two dorsal warts on the ninth abdominal segment.

The caudal horn in the Bombycidae shows no resemblance or affinity to that of the Ceratocampidae, and here I may state that the small family Bombycidae has no relationship with the Ceratocampidae or Saturniidae; on the contrary the family is intimately related by its larval and pupal characters with the Lasiocampidae, and I am inclined to the view that the Bombycidae have actually originated from the Lasiocampidae, their larvae having undergone a process of acceleration, while the moths have been modified by atrophy of the veins and mouth-parts. On comparing the caudal horn of *Bombyx mori* with that of *Gastropacha* (Epicnaptera) *Americana* it was found to be similar in structure and armature, though that of Epicnaptera is broad, short, flat, and conical. On further comparison of the fully-grown larva of the two genera I was surprised to find how nearly allied they are. The head of *Bombyx mori* (Pl. XIIV, fig. 5) is of the same peculiar shape as in the Lasiocampidae, and densely clothed with long hairs; they are alike also in the nature of the tergal region of the prothoracic segment, though *B. mori* is without the prominent lateral tubercles so diagnostic of the larvae of Lasiocampidae and Lymantriidae. In the ninth segment as regards the shape of the suranal plate and of the anal legs, *B. mori* is closely similar to those of Epicnaptera. I conclude, then, that the Bombycidae being essentially lasiocampids in their larval characters, as imagoes the group became modified by retrograde development and formed a downward bent side-branch of the lasiocampid stem. We have here a clear example of the evolution by atrophy of one family from another. Dyar<sup>a</sup> states that the warts of *B. mori* are "true warts of the typical lasiocampid pattern." He places the family near the Lymantriidae. To Professor Sasaki<sup>b</sup> we are indebted for an account, with figures, of the first stage of the wild silkworm of Japan, which Sasaki identifies as *Theophila mandarina*, and its descendant or derivative *Bombyx mori*. In both of these forms there is already in stage I a single median wart on the eighth abdominal segment. This shows that the larva has undergone, just as in Epicnaptera, before hatching an acceleration of development as regards this pair of warts. After the first molt the caudal horn is developed. Sasaki observes: "After the second stage there are no marked changes in both color and markings till the larva becomes mature."

I have always supposed that the Bombycidae were more nearly allied to the Saturniidae, since they have but three branches to the median vein and atrophied mouth-parts, but we now see that these reduction characters are not diagnostic of any particular group of families, but may occur in any group as the result of disuse and loss of power of flight in the imago. Here, as elsewhere in the insect and animal kingdom, the larval or postembryonic character as a rule, though there are exceptions, afford the truest guide to the phylogeny of a group.

It is interesting to observe how the armature of certain species of *Bombyx* and allied genera repeats in general appearance that of the ceratocampid genus *Adelocephala*, etc., though the resemblances are surely cases of convergence, due perhaps to their living on trees whose twigs are either tuberculated or spiny.

The two most striking cases of mimetic analogy, parallelism, or convergence are seen in the larva of *Theophila huttoni*, described and figured by T. Hutton. In the newly hatched caterpillar there is, he says, "a small anal tubercle on the penultimate segment; thus far there is scarcely a difference between it and the young Chinese worm." This is evidently the same as the incipient caudal horn of the larva of the same stage of *Bombyx mandarina* and *B. mori*. After the first molt the warts become converted into short, conical, fleshy tubercles or spines. In the mature larva "there are two dorsal rows of long, black, slender, and sharp-pointed spines, commencing with the fifth [second abdominal] segment. While the median spine is thus fused or double, the warts on the ninth segment of stage I become long spines about as large as the caudal horn.

<sup>a</sup>On the larvae of the higher Bombycidae. Proc. Boston Soc. Nat. Hist., XXVII, p. 140, 1896.

<sup>b</sup>On the affinity of our wild and domestic silkworms. Annotationes Zoologicae Japonenses, ii. Part II, June, 1898. pp. 33-40.

"In other genera of this family, as the species of *Ocinara*, in which the body is slender, there is a caudal horn. In *O. signifera* there is a well-developed caudal horn, while the body is humped on the second thoracic, second and fifth abdominal segments. Indeed, it bears a close resemblance in general appearance to certain geometric or measuring worms, such as *Ennomos*, *Eutrapela*, *Eugonia*, etc."

"It is worthy of notice, as bearing on the use of these horn-like tubercles as offensive structures, that Captain Hutton states that the extremity of the horn is retractile and is generally withdrawn into the lower part as a sheath; when the animal is about to molt, or is disturbed and irritated, the summit of this spine is exserted, and instead of being brown, like the base, is whitish; when exserted the whole stands erect, slightly inclining backward."

Horsfield and Moore figure the larva of *O. dilecta* of Java as having a horn.

*The caudal horn of the Sphingidae.*—Much has been written on this subject. In 1882 Mr. Meldola, in the appendix to his translation of Weismann's "Studies in the theory of descent," calls attention to the caudal horn of sphinx larvae, mentioning that in the young larva it is "freely movable," adding: "It is possible that this horn, which was formerly possessed by the ancestors of the Sphingidae, and which is now retained in many genera, is a remnant of a flagellate organ having a similar function to the head tentacles of the *Papilio* larvae or to the caudal appendages of *Dicranura*."

Poulton (1884) concludes that the forking of the horns is a primitive character and observes that it is movable in the two first stages of *S. ligustri* and under the control of the animal's will. He also quotes notes from Mr. R. Trimen on the young larva of *Lophostethus dumolinii* Angus, in which it is stated that the anal horn is, like the dorsal thoracic spines, "distinctly forked" at the extremity. Mr. Meldola adds that "the forked caudal horn in the young larva of this species is of interest in connection with the similar character of this appendage in the young caterpillar of *Hyloicus pinastri*" (p. 527).

The caudal horn of the fully grown larva of *Lophostethus dumolinii*, which is well figured by Lieut. Col. J. M. Fawcett,<sup>a</sup> differs from that of all other known sphingid caterpillars in being a solid chitinous spine, sharp, not forked, and with several setae, being in fact, judging by the figure, no stouter, longer, or differing in any respect from the thoracic horns.

Wilhelm Müller, in 1886, at the close of his memoir, figures the end of the body of the larva of *Diloptonota* and discusses the caudal horn of the Sphingidae, considering that it has the same origin as the unpaired horn of the Saturniidae, remarking: "Both have arisen from the supporting structures [tubercles] of the two bristles upon segment 11." He concludes that the caudal horn of the Sphingidae is the remains of another armature perhaps referable with that of the Saturniidae of the present day to a common source, so that the caudal horn of the Sphingidae and the caudal spine (*Ds* horn) of the Saturniidae are in the fullest sense homologues.

The present writer has paid especial attention to the double nature of this tubercle in the different groups and genera of the Ceratocampidae, Hemileucidae, and Saturniidae, the facts being stated in the course of the description of the larvae in different stages and affording strong proofs of its origin from the fusion of the two tubercles.

Besides the caudal horn of Ceratomia, already described, I have previously stated<sup>b</sup> that in stage I of *Pueria excavatus* the caudal horn is distinctly forked at the tip, and that in stage III it ends in two tubercles. In *Sphinx kalmiae* in its second or third stage the horn ends in three or four tubercles, but in stage IV<sup>c</sup> there are no definite traces of a fork. In a Sphinx found on the larch the horn is smooth, but ends in two fine setae. In a lot of freshly hatched Sphinx larvae of an unknown species the horn is distinctly forked.

In a full-grown *Sphinx cheris* the end of the horn is smooth and undivided. Pl. XLII, Fig. 3, represents the end of the caudal horn of *Pueria myops*, the tip ending in two rounded smooth tubercles without a seta, though the rounded spinules below each bear a distinct seta; *a* represents the tip as seen from the end, showing the rounded ends of the fork.

<sup>a</sup> Trans. Zool. Soc., London, XV, April, 1901.

<sup>b</sup> Proc. Boston Soc. Nat. Hist. XXV, p. 103, footnote, 1890. Compare also C. M. Piepers, Ueber das Horn der Sphingiden-Raupen, Tijdschr. v. Ent., XL.

#### IV. PROTECTIVE ARMATURE BOTH IN SHAPE AND COLOR AND DEFENSIVE MOVEMENTS.

Referring to the aggressive or defensive movements of the caterpillars of *Adelocephala*, Dr. Jewett remarks: "Up to the third molt the larvae when alarmed move the protuberances on the second and third segments as if to frighten away the intruder."

In my Notes (p. 150) I remark regarding them in the second stage: "In this stage upon touching or teasing the larva the thoracic spines spring out; at the same time the head, together with the thoracic region, jerk violently, as if to beat off an intruder. Also, when two caterpillars meet they evidently attack each other, butting and striking with their horns like two hostile goats, deer, or cattle. It seemed evident, after repeated observations, that the great thoracic spines are of real defensive use." Again, in referring to a larva in the fourth stage: "it would appear probable that the formidable spines of the grown-up caterpillar save it not infrequently from being swallowed by birds, though the horns are probably of greater use in the earlier stages, when they are much longer and much more movable, in frightening away ichneumons and Tachinae. For example, even when 20 mm. in length, a larva was seen when teased to spread apart its great arm-like horns, while the full-fed ones did not notice such stimulus."

It was also added that in the larvae of the last stage, instead of being green as in the earlier stages, they become roseate pale coral red, and "not so near in tint to the spines of the food plant as in the young. When the caterpillar is at rest they are held close together in a recurved position, and in the grown-up larva when touched they are not moved or the body jerked in response to such stimulus."

"The horns in *Sphingicampa* are not held spread out as in *C. regalis*, but those of each pair are constantly held close to each other. The horns and the six silvery, opalescent, shining tubercles probably become terrifying by the movements of the larva. The latter are turned on and throw their light out suddenly like flashes, and may thus have a deterrent effect on their enemies." (Proc. Amer. Phil. Soc., XXXI, p. 157.)

It is worthy of note that the larvae of most of the species of this genus feed on spiny plants, one, *A. bicolor*, on the spiny or honey locust.

In Brazil, according to Peters, *A. mardi* lives on a spiny mimosa whose leaves on the underside are violet brown; *A. subangulata* lives on a spiny climbing plant, *A. brevis* on a thorny mimosa in the gardens of Rio Janeiro, and the caterpillars of an undescribed species on an acacia.

These caterpillars, with their remarkably long spines, including those figured by Peters and by Burmeister, have the dorsal spines of the abdominal segments nearly or quite as long as those on the thoracic segments. As these larvae are quite large, and their spines in some cases from a half to an entire centimeter in length, they would easily be mistaken by birds and lizards, as well as monkeys and other mammals, for the smaller spines of the trees or shrubs on which they feed, especially when not in motion, and it is a question whether they are not more useful as mimicking the spines of their food plants than as simply defensive structures. Yet a bird, or even a lizard, might hesitate before swallowing such spinose creatures.

As to the origin of these great spines and their adaptation as protective structures it is not easy to frame a hypothesis. To suppose that they arose by natural selection is scarcely an adequate explanation, though this may account for their preservation after they have once been developed.

#### V. COLORATION IN THE LARVÆ OF THE CERATOCAMPINÆ.

We will begin with the species of *Anisota*, in which the armature, owing to the reduction of all but the pair of slender thoracic horns, is reduced, and becomes subordinate to the coloration. This is especially seen in *A. senatoria* where the alternating deep ochreous and black-brown bands are so prominent, the effect of the black spines in most cases being lost, owing to the position of those of the dorsal and subdorsal series in the dark brown or blackish stripes.

As regards coloration, *A. rubicunda* appears to be the most primitive or phylogenetically oldest species of the genus. When hatched (stage I) there are no stripes, the larva being of a pale yellowish green, the traces of the longitudinal stripes appearing toward the end of the stage and the larva, having fed, becoming greener in color. The green color in this species alone persists throughout larval life, the alternate stripes being lighter or darker green, according to the amount of green pigment deposited in the hypodermis. It is to be observed that the dark green stripes are no more accentuated dorsally than on the sides. The green hue is a protective one, most larvae being green, and hence this species needs less spiny structures than the others of the genus. Here it might be observed, what is well known to every entomologist, that the underside of all lepidopterous larvae is usually paler than the upper, due to the lack of pigment. This, as in all animals in which the underside of the body is lighter than the upper, is due to the absence of direct light rays and of the resulting stimulus to the deposition of pigment, the underparts being in the shade. This is the case also in fishes, reptiles, birds, and mammals.

Yet in some caterpillars there may be a dark ventral median line or stripe, and in *Apatalodes torrefacta* (Pt. I of this Monograph, Pl. IX, fig. 6.) there are two or three conspicuous black patches on the underside of the body, yet the larva may occasionally assume a posture revealing these marks.

It is noteworthy that in *A. rubicunda* all the green stripes, so far as we have observed, appear at once along the entire length of the body, not apparently first originating at the end of the body. But further observations are needed as to this point.

*Origin of the lateral (Infraspiracular) red band.*—Nearly all lepidopterous larvae have along the sides of the abdominal segments 1-8 a lateral ridge, or salient, somewhat fleshy, convex, longitudinal fold, more or less regular, situated beneath the spiracles or spiracular line. This ridge or fold, which is continued behind by the edge of the suranal plate, is apt in many caterpillars to be pigmented with red or yellow, these tints appearing on the upper or more exposed surface, while the lower side is pale or whitish, the shading being more or less gradual.

In the second stage of *A. rubicunda* this lateral ridge begins to be colored red, forming an obscure line, which originates on the eighth and ninth abdominal segments and passes forward to the first thoracic segment, though fainter on the anterior half of the body. This reddish line may have been inherited from some extinct form, because in the third and subsequent stages it disappears from the front and middle of the body and becomes restricted to abdominal segments 8 and 9. On these segments it forms a very conspicuous mark, being bright crimson or vermillion. The body is also a little flattened on these segments, so that the spots show from above. I have not specially noticed the larva while resting on a maple leaf, but am disposed to think that these two vermillion or reddish patches harmonize with the reddish petiole of the leaf of this tree, and are thus protective. It is also noticeable that this line, originating at the tail end of the body, is another example of the origin of certain new kinds of markings at the posterior end of the body.

In the majority of the species, namely, in three out of the five whose transformations are known, the longitudinal bands are either pink or grayish, and this style of marking thus seems to have been the one most advantageous to the species. The lower lines in *A. virginianensis* and *stigma*, corresponding to the reddish line in *A. rubicunda*, is pink, and of the same hue as the subdorsal line. The tint appears in stage II, and remains in all the subsequent stages, extending along the whole length of the body. They do not, so far as we have been able to observe, originate at the end of the body. In stage II there are no signs of them.

*A. senatoria* is the most conspicuously marked larva of the genus. Unlike *A. rubicunda* and the other species, it remains gregarious throughout larval life, clustering in great numbers on the terminal twigs of the oak, after the leaves have been devoured, so as to be very conspicuous, yet they appear to be avoided by insectivorous birds. Whether they are poisonous or not we do not know, but the bright, deep ochreous stripes alternating with the black ones are probably warning colors.

What in *A. rubicunda* are dark green stripes become black in *A. senatoria*, while the deep ochre or scotch snuff ones correspond to the pale green stripes of *A. rubicunda*. All the spines

in *A. senatoria*, except the horns, blend with the black tints, except those in the ocherous infraspiracular line. These black and ocher lines appear in stage IV, the black ones arriving in stage II. In stage III the larva is still olive green, with yellowish dorsal and lateral lines. The head in this species is persistently black from the first to the last stage. It is finally to be observed that in this genus color and bright stripes are of more importance than spines, whereas in Adelocephala the armature is emphasized and the markings are a quite subordinate feature.

*Coloration in Adelocephala*.—In the fully grown caterpillars the body is grass or pea green, with usually no gay markings, and the spines bristle with large stout saber-like spines, those of the abdominal segments being in certain species nearly as large as those on the two hinder thoracic segments. Hence they are admirably protected from attack, since the horns are both defensive, and also harmonize both in shape and color with the spines of their food plants.

Not so, however, with their ancestors, which, judging by the life history of *A. bicolor*, especially its markings in stage I, were, besides wearing long, knobbed, reddish horns, gaily and conspicuously striped. *A. bicolor* on hatching is green, with three lateral white stripes and a narrow thread-like red dorsal line ending on the red caudal horn. The head is black, while the eight thoracic horns are all red, or reddish, including the subglobular ends. As regards the remarkable distinctness of these stripes, we infer that if we take into account the coloration alone Adelocephala is a more primitive form than any other of its subfamily. Its ancestors must have been so marked at larval maturity, and here we have a very clear example of the crowding back to the first stage of the ontogeny of features characterizing the later and last one, and its life history is a partial recapitulation of that of its ancestors. The horns in the earlier stages, when the larvae may be huddled together on the underside of a leaf, are of no use to them, and in the final stages they tend more and more to be reduced and to lose their brilliant red coloring, though in the mature ancestral caterpillars both the distinct lines, the threatening forest of long banner-like horns at the front and one at the end of the body must have rendered them inedible, or at least unattractive to insectivorous animals.

The ancestral caterpillar must have lived exposed to the sunlight, as the green stripes are due to the greater abundance of chlorophyll, the white to a deficiency of pigment, such lines being the effects of light and shade and very common among lepidopterous larvae.

In the second stage the head is reddish, and the spines still red, the small ones along the abdominal region yellowish. A new colorational feature is a narrow, thread-like red line connecting the spiracles, becoming yellow on the edge of the suranal plate.

In stage III there are the same tints, but the lower side of the red lateral line is shaded whitish yellow, while the line on the ninth segment and along the edge of the suranal plate is all yellow. This line in front passes up to the base of the second pair of thoracic horns, so as to give the appearance of a continuous red line, this being a concealment feature.

In stage IV the red portion of this line becomes purplish above, probably due to the reflection of the purplish parts of the leaves. Now all the spines have lost their red color and have become yellowish, hence much less conspicuous than before, and in the last stage the body is plain green, the shades given off from the pale yellowish horns and silver dorsal spines, as well as the purplish red and white of the lateral stripe blending with the hues of the leaves and spines of the honey locust. It should also be observed that the yellow edge of the suranal plate shows from above.

It may be concluded that all the colors and hues, as well as the spines of the beautiful larva of *A. bicolor*, naturally blend with or match the hues of the leaves and spines of its food plant.

Certain of the Brazilian forms have apparently no red lines. In one we possess (Pl. III, fig. 1) the body and spines are uniformly grass green. In *A. argyracantha*, figured by Burmeister (our Pl. XLIX, fig. 1), the body is uniformly green, and there are no red lines or spots, while the spines are yellowish.

In the Brazilian *A. wardi* the body is green, but the larger dorsal spines are very brilliantly silvery, the smaller ones violet, and on the side of the body are three conspicuous, very large, wide white bands, and the head and thoracic legs are also white. The larva of *A. subangulata* and *brevis* have a bluish head and lateral stripe.

*Coloration of Syssphinx.*—The larva of the last stage has a thick green body, with the horns and spines much reduced, while the lateral stripe is yellow. Hence this form is protected simply by its green color. Its young, freshly hatched larva, judging from alcoholic examples, is plain green, without stripes, but with long, large horns, much as in *A. bicolor*.

*Coloration of Eacles imperialis.*—We now have an entirely different style of markings in this genus. In the freshly hatched young of this polyphagous form there are no longitudinal stripes on the pale sienna-brown body, but the abdominal segments 1 to 7 have each two narrow regular parallel dark brown bands across the back, with either one or two short ones on the side reaching up to or a little beyond the spiracular region. The body is very spinose, the four thoracic and the caudal horn very long and deeply forked, and pinkish. From what ancestral form this unusual style of markings has been derived is difficult to conjecture. The hue of the body is similar to that of the sheathing base of pine needles.

This style of markings is retained in the next stage, but the spines are somewhat reduced, and are now black. At the second molting the larva enters on its third stage with no markings, while the horns are pale, black at tips. After a third ecdysis the body is green (sometimes reddish brown); the horns are reddish and the spines are yellow, as are the suranal plate and anal legs and thoracic legs; the head is partly banded with yellow, while the midabdominal legs end in yellow. The spiracles are in stage IV noticeable from the rich dark green ring in them, the color of the pine needles.

These hues and markings are apparently protective, the caterpillars, both the green and brown forms, in the Northern States being most common on the white pine.

In a larva of *E. penelope*, living in the high mountains of the interior of Brazil, Peters figures a form somewhat like *E. imperialis*, but with two violet dorsal bands bordered with white. This kind of marking is exceptional and apparently unique in this subfamily. It lives on a melastomaceous plant and also on the guava (*Psidium pomiferum*); neither of these plants is spiny.

It is questionable whether the caterpillar of *E. imperialis* originally lived on the pine, though when feeding among the needles it is not readily detected.

*Coloration in Citheronia.*—Unlike Eacles, the two species of the present genus, the only ones whose earliest larval stages are known, are not marked with bands either longitudinal or transverse, or any spots. In *C. regalis* and *septentrionalis* the body at birth is either dusky pale on the upper side of abdominal segments four to six (*C. regalis*), or pale yellowish brown and dusky on the dorsal side of abdominal segments five to eight (*C. septentrionalis*).

The markings, or rather their absence in this stage, throw no light on the relationships of this genus, whatever may be said of the armature.

After the first molt *C. regalis* is reddish and *C. septentrionalis* yellowish. Now, some very interesting stripes appear in *C. regalis*. On each side of the back of abdominal segments one to eight are three short, dark, irregular longitudinal bands, the *lowest of which is directed a little downward and extends under the spiracle, this becoming the oblique band*, a characteristic color-mark of this genus, not usually present in the Ceratocampidae. Unlike the oblique stripes in the majority of the Sphingidae, these stripes pass from the front edge of the segments, and also do not overlap on the succeeding segment. This is also the case with the corresponding markings in the Saturniidae (Telea, etc.). The two shorter upper bands are not retained, but disappear with the second casting of the skin.

In stage III the seven pairs of oblique stripes are dark above and pale beneath. They probably harmonize with the dark twigs of the food tree.

Those in *C. septentrionalis* arise in the same way, there being at first three, though more obscure and irregular, and in this species two are retained, only one being eliminated; there being on each side a distinct straight dorsal stripe, besides the oblique one situated in front of the spiracles which is not quite so long as in *C. regalis*. We thus see that colorational features in these two species appear to be more stable than the armature, since the two species under discussion belong, as regards the armature, to two quite different sections of the genus.

In the full-fed larva of *C. septentrionalis* there are no definite stripes, the oblique ones are not present.

In *C. regalis*, especially, the oblique, black stripes are continued by the large conspicuous black spiracles, and also by the black stripe on the outside of the mid-abdominal legs. Thus the effect of the stripes themselves is heightened and extended by these supplementary markings situated in line with but below the oblique stripes.

In stage IV the oblique stripes are more diffuse, broader, and reach so as to almost include the spiracles, which are as large as in stage V and last, and from each spiracle a black stripe descends obliquely to just behind each infraspiracular spine, and then blends with the black stripe on the mid-abdominal legs, though there is no corresponding stripe on the other legless abdominal segments. It is also to be observed that the blackish oblique stripes are confined to a single segment, not passing on to the next one, and an oblique antero-posterior stripe extending from the front edge of the segment down to the spiracle is the reverse of what obtains in the majority of the Sphingidae.

In stage V, *C. regalis* (in a dried, blown example) is rather less blackish than in stage IV, and under each blackish stripe is a pale shade. The spines are also much smaller, so that the larva is less black; the light shade is a little wider than the black band itself.

Another set of black markings is the great dorsal black patches on the second and third thoracic segments of stages III to V, and the narrow cross-band between the third thoracic and first abdominal segments; their significance may be cleared up by observations on the living insect.

#### VI. DICHROMATISM OR COLOR VARIATION IN THE LARVA.

The best-known case of dichromatism in larvae is that of *Thysanus abbotii*, described by Riley, in which there is a dark brown and a green form. Lieutenant-Colonel Fawcett describes a dark form of the larva of *Protoptice mauritii*, of Natal, while *Acherontia atropos* is said by Trimen to have a dark form at Cape Town. Light and dark color varieties have been artificially produced by Prof. E. B. Poulton. Mr. Meldola had previously (Proc. Zool. Soc., London, p. 155, 1873) called attention to the fact that the younger larvae of *Geometra papilionaria* are brown, "and remain brown during hibernation, when the leaves are bare, while many of them become green when older, after the leaves have expanded in spring." Mr. Poulton also discovered that "the younger larvae possess the power of adjusting the shade of their brown color to that of the twigs of their food plant." Mr. Meldola calls this phenomenon "seasonal adaptation," and besides the species mentioned he cites *Avidalia degeneraria*, and *Gnophos obscurata*, adding, "and many more could be named."<sup>a</sup>

In *Eacles imperialis* there are two color forms, i. e., a normal green and a brown form. They do not, however, seem to be phytophagous varieties, as both occur on the white pine.

While the caterpillars in the early stages are usually a light yellowish or clay brown, in the fourth and last stages they vary in being either pale green or reddish brown. As these caterpillars are not common, it is not easy to state the proportion of brown to green individuals. From what I have seen, I should suppose that the green in the two final stages were the normal or more common, and the brown were more of the nature of aberrations.

Mr. Bridgham has, more commonly, found the pale green form on the white pine at Providence, though the brown form occurred on the same tree.

I will describe the color forms in my possession:

*The green form—Stage IV.* The body of a blown example is pale green; the hairs very long, white, and rather thick; the head is pale ochreous, paler than in the reddish brown blown specimen, and of the same hue as the thoracic legs. The thoracic horns and other spines are

<sup>a</sup> Meldola also states that the larvae of *Emmelesia unifasciata* feed on the seeds of a species of *Bartsia* when the capsules are in various stages of growth, "and those caterpillars found on the green capsules were green, whilst those on the brown capsules were of a corresponding colour." (Trans. of Weismann's "Studies in the theory of descent," I., p. 307, 1882.)

pale reddish but much paler at base; the caudal horn much paler than the thoracic ones. There is a black ring around the base of the thoracic legs. The spiracles are deep purple around the edge, those of the eight abdominal pair darkest, becoming paler toward the first segment; the prothoracic ones only partially stained with purple. In Bridgham's drawings the spiracles are drawn with a blackish ring (Pl. IX). The midabdominal legs are dusky brown at base, and the plantae blackish. The anal legs or claspers and also the suranal plate are yellowish, but black in the middle area, though the granulations are yellowish. The head has a dark short line on each side, and two diverging dark lines on each side of the clypeus.

*Stage V (last).*—A blown specimen is uniformly deep pea green, with no brown shade. The head is as in Stage IV, but green behind the yellowish front. The spines are yellow, with no red discoloration on them. The spiracles are deep purple, and do not become paler anteriorly. They are drawn bluish purple<sup>"</sup> by Mr. Bridgham (Pl. IX). The suranal plate and anal legs are identical in coloration with those of Stage IV.

*The brown form.*—I will first describe a fully grown blown example of the same size and shape as the above-described green larva. The body is reddish brown; with three paler, clearer, subdorsal diffuse irregular patches on each segment, forming two obscure broad interrupted longitudinal bands. The region about each spiracle is also paler brown, forming an oblique oval patch, passing from the front edge of the segment downward. The pale yellowish spiracles are very conspicuous and are surrounded by a dark purple ring. The spines are fully as stout as in the green form, and the body is equally hairy, the hairs being whitish. The head differs from that of the green form in the greater amount of dark brown, both on the sides and along the middle in front, yet the back part of the sides, that corresponding to the green portions in the green larva, is dull obscure yellowish. The colors of the suranal plate and of the anal legs are much as in the green form, but a greater extent of the anal legs is black-brown. The thoracic legs are yellow, but the midabdominal ones dark brown.

*Stage IV.*—It differs from the green one of this age in being bright reddish, the tubercles of the same hue, while the head is reddish, as are the legs, thoracic and abdominal, while the edges of the suranal plate and anal legs are tinged with reddish. The spiracles are surrounded by a brown ring.

A third form, a true dimorphic form, appears to be that represented on Pl. VIII, fig. 6. I will describe a specimen received by exchange from the museum of the Brooklyn Institute. It differs structurally in the slightly stouter tubercles and denser hairs. In color it differs from the brown form above described in being of a rich, dark umber or Vandyke brown. The subdorsal row of pale sienna brown patches is more distinct, and the series is made up of a single large squarish patch, situated on the front edge of each segment, except the prothoracic and the ninth and tenth abdominal. The spiracles are conspicuously straw-yellow with a brown ring (I can detect no purplish hue in the dried specimen); the oval oblique patches inclosing them are of the same hue as those on the tergum, and also those of the brown form. The head (Pl. VIII, fig. 6a) is nearly all black-brown on the sides and in the middle, leaving an irregular yellow band on each side of the front; the anterior clypeus and labrum are also yellowish or luteous. The suranal plate is dark brown, as are the anal legs, except the front edge of the legs, which are yellowish; the secondary tubercles or granulations are yellowish. The thoracic legs are yellow and black; the midabdominal ones brown-black. The tubercles are all black-brown.

*The three color forms of Citheronia regalis.*—Mr. A. Hyatt Verrill has called my attention to some striking color variations of this caterpillar, of which he took photographs in color somewhat touched up by hand. The variations are in green, green and orange, blue, and brown. My notes are taken from his colored photographs as I have not yet had the fortune to see the larva of this species while alive.

In all the forms the size, shape, and colors (orange, red, and black) of the spines are the same, as also the color of the head, thoracic and abdominal legs, and the suranal plate.

<sup>"</sup>In the plate, however, they are unfortunately printed black.

1. *The green form*.—(Pl. XXI, fig. 1, see also Riley's figure in Amer. Ent., i., Pl. 1) (*a*) It lives, or at least the examples collected, lived on the hickory. The general hue is a rather dark olive-green, becoming slightly paler above, and pale turquoise blue around the bases of all the spines. The seven oblique lateral infraspiracular bands are paler, of a deep pea green. (*b*) The green-orange form. It lives on the hickory. It differs from the entirely green form in the orange tint on the back of abdominal segments 1 to 8. The lateral oblique bands are turquoise blue, and the blue around the base of the spine is deeper in hue, while the ring around the spiracles, instead of being orange-red as in *a*, is now deep blue.

2. *The blue and orange form*.—Pl. XXII, fig. 1. It feeds on the butternut. The entire body above is turquoise blue, including the oblique lateral stripes, which are deeply shaded on the lower edge. The spiracles are tinged with orange, and there is a patch of orange behind each abdominal spiracle of the third and fourth abdominal segments. On asking Mr. Verrill whether the colors of his photographs are not too bright he replies: "The color, however, is none too bright even on the blue form; in fact, the brilliancy of this variety can hardly be imagined. It is such an intense opalescent blue that it resembles blue enamel more than animal tissue. When the caterpillars are first secured I always make a hurried water-color sketch to be sure of the exact shade, and if in the photograph the tints are not true they are touched up by hand."

*The brown form, stage IV.*—(Pl. XXIII, fig. 1.) A brown form (*a*) was found feeding on the ash. The ground color appears to be an olive green, with a faint orange tinge shading into a reddish brown. The horns and spines are all dark black brown. The oblique lateral bands are very conspicuous, and are of a bright olive-green hue. (*b*) The pink form (Pl. XXII, fig. 2), also living on the ash, was in the fourth stage. The body is uniformly pale reddish or madder brown, with a slight pink or carmine tinge. The two large dark thoracic dorsal patches instead of being black are deep madder brown; the head, all the legs, both thoracic and abdominal, and the armature, as well as the suranal plate, are of the same hue as the body. The oblique lateral bands are much paler, almost pinkish."

It would be most desirable that some future observer favorably situated should ascertain the exact conditions of the environment under which these colored forms have been produced, how permanent they are, and whether hereditary or only confined to the lifetime of the individuals themselves.

In 1892 Professor Poulton<sup>a</sup> studied experimentally the adjustment of the colors of the larva of *Amphidasis betularia* to those of their environment, and in 1903<sup>b</sup> he published the results of experiments on another geometrid larva, *Odontopera bidentata*. This larva is extremely sensitive, with a power of adjustment about equal to that of the *Amphidasis*, "the most sensitive larva hitherto known." A large number of records proves that the larvae, in the great majority of cases, rested by day upon the objects, lichen-covered twigs, whose hue they afterwards came to resemble, though this is "probably not the case in the earliest stages, when the larva doubtless rest on the leaves and stalks." "The effect of green leaves alone upon *bidentata* is the same as that observed in many other larvae, Noctue as well as Geometrie, viz, the reduction of the brown ground color to a very pale tint which would be far less conspicuous than the more ordinary appearance." *O. bidentata* appeared to be more sensitive to lichen than *A. betularia*, but less sensitive to green leaves, though the two species are "about equal in the power of color adjustment." And Poulton adds, "lichen must have been the cause of the *betularia* larvae, with one exception, becoming green, for ordinary bark tends strongly to the production of dark forms

<sup>a</sup> From Mr. Verrill I have also received colored photographs of a green and of a pinkish form of *Ampelophaga myron* on the grape vine; also of the red form of *Cressona juglandis*, and a red form of *Apatela beumosa*.

<sup>b</sup> Further experiments upon the color relation between certain lepidopterous larvae, pupae, cocoons, and imagines and their surroundings. Trans. Ent. Soc. London, Dec., 1892.

<sup>c</sup> Experiments in 1893, 1894, and 1896 upon the color relation between lepidopterous larvae and their surroundings, and especially the effect of lichen-covered bark upon *Odontopera bidentata*, *Gastropacha quercifolia*, etc. Ibid., Oct., 1903.

of this species, even in the presence of a great preponderance of green leaves." (Trans. Ent. Soc. Lond., 1892, pp. 331, 332.)

The larva, says Mr. Poulton, never rested upon the lichen itself, but upon the back of the sticks between the masses of lichen. "This position is consistent with the larval appearance, which is that of bark partially grown over with lichen."

"There can be little doubt that the larva is influenced by the colors of the environment from the time at which it first seeks the older wood, but a certain period is required before the effects become visible."

"The same relationship between susceptibility and the particular needs of each species is seen in the effect of an environment of green leaves and shoots upon *G. quercifolia*, *O. bidentata*, and *A. betularia*. The first named probably invariably rests by day, except for a brief period after leaving the egg, upon the older wood, and the power of adjustment to leaves and young shoots, being altogether useless to it, has never been acquired. The last named, with its remarkable range of food plants, including many such as broom or rose, in which green shoots are a prominent feature, is frequently in a position in which a green color could best conceal its nearly smooth and cylindrical form; and we find that, as a matter of fact, it always responds in this way to an environment of the kind described above. *Bidentata* doubtless occupies an intermediate position between the other two species in this respect. The occasions are probably rare, but not altogether wanting, in which it is compelled to develop in a green environment. We find that it has the power of making some considerable approach toward such surroundings, but not of attaining any high degree of resemblance to them. It is probably the case, however, that the tint which it produces on green leaves and shoots is of great value on a pale yellowish-brown bark, which may often form its environment; and it may well be that it is something in common between the light reflected from this and from green leaves, which explains the similarity in the effects produced upon the larvae."

In his essay of 1902 Professor Poulton draws the following conclusions:

"The other larva (*Smerinthus*, *Sphinx*, *Aglia*) which I have tested are very inferior to the genus *Catocala* in this respect, but from what Colonel Swinhoe tells me it is evident that some of the Indian *Sphingidae* are highly susceptible.

"There may be a most extraordinary fluctuation in the amount of susceptibility within the limits of the same genus (*Catocala* and in the pupae of *Papilio*).

"In *Geometrae* alone have distinct green larvae been produced by these experiments. Probably the great majority of these larvae are sensitive. Out of 11 species, many of which were selected at random, all but 1 have proved to be so.

"There is no evidence that the results acquired by one generation can be transmitted to the next (*Rumia*, *Crocallis*). The susceptibility is essentially an adaptation to the fact that the individuals of each of such species are liable to find themselves in different environments, so that any bias from the experiences of the past would of course be injurious, unless the earlier and later surroundings happened to correspond.

"In the case of *R. erithreogaster* the test for hereditary effects was as complete as it could be in one generation.

"Concerning the time which is necessary before the color changes begin to appear—

"Some effect was produced in eight days in young *G. papilionaria*.

"Some effect was produced in eight days in young *C. electa*.

"Much effect was produced in twelve days in young *C. dionguearia*.

"Much effect was produced in about fourteen days in young *M. montanaria*.

"Much effect was produced in about eleven days in young *C. cloacata*.

"Much effect was produced in thirteen (or less) days in young *H. abruptaria*.

"Much effect was produced in seventeen days in young *R. erithreogaster*.

"Much effect was produced in eight days in young *A. betularia*.

"When carefully watched for, the changes are sometimes seen to occur quite suddenly (*C. elinguaria*, *R. crataegata*, 1886, II)."<sup>a</sup>

"The effects can not be reversed by reversing the surroundings for a short time (*C. elinguaria*, *H. abruptaria*, *A. betularia*).

"When the conditions are uniform the response to environment does not necessarily destroy individual variability, but the most powerful forms of environment, when applied to highly sensitive species, very nearly do away with it.

"If the environment be mixed there does not appear to be any instinctive knowledge leading the larvae to rest only on appropriate objects. Thus, if they have become green and are beyond the power of change, they will nevertheless rest on brown twigs in preference to leaves, if offered to them.

"The instinct of these *Geometræ* is to rest upon twigs under any circumstances, and this is probably the reason why so small a proportion of things produces so great an effect (*A. betularia*, 1889). Contact, or at all events the closest proximity, is required to effect the change. Although they are so much more susceptible to brown surroundings when these are mixed with green, there were *no* exceptions among 105 larvae which, in 1889, became green among leaves and shoots.

"The effects produced on the larvae do not influence the colors of the moths (*A. betularia*).

"Darkness does not produce so great an effect as black surroundings in strong light (*A. betularia*, *R. crataegata*, *C. elinguaria*). Overcrowding tends to produce dark larvae (*A. betularia*, *R. crataegata*).

"In the case of *R. crataegata* and *A. betularia* there is direct evidence of the power being efficient in concealing the wild larvae. The larvae are probably chiefly sensitive at the time when they quit the leaves and first begin to rest on the twigs."

## VII. LIFE-HISTORY OF CERATOMIA AMYNTOR.

(Plate XXXIV.)

The eggs were kindly sent me from Brandon, Vt., by Miss Caroline G. Soule. They were deposited on the night of July 31, and the larvae hatched out at Brunswick, Me., early in the morning of August 9.

*Egg*.—Large, oval, though nearly spherical, being but little longer than thick; it is not flattened, as in the Ceratocampinae. The shell is very thin and transparent, and under a strong hand lens is seen to be minutely pitted. Length, about 1.7 mm.; breadth, 1.5 mm.

*Larva, Stage I* (fig. 1, 1a).—Length when hatched, 4.5–5 mm., becoming at the end of the stage 12–13 mm. Its general shape and proportions are much like those of *Eacles imperialis*, though slenderer, and the close similarity in the shape of the anal legs aid in the resemblance. The head is, on escaping from the egg, about twice as wide as the hinder part of the body, being 1.5 mm. wide; toward the end of the stage, after the body is filled out, it is no wider than the body.

The head and body are very pale, whitish, glaucous green, the head and body of the same hue, the latter at first with no definite markings. The head is smooth, with no traces of fine, short spinules; the trunk segments are also smooth, with no secondary spinules.

<sup>a</sup> I have observed that the flower-spider (*Misumena vatia*) requires at least a week or ten days to change from white to yellow. This species is translucent and probably changes sooner than others of its family. G. Pouchet first studied the faculty of adjustment of the color of shrimps to that of their environment, which faculty he calls the "chromatic function" and which is due to the movements under the stimulus of light of the pigment cells (chromatophores). He found that in the turbot the color changes were only developed after the lapse of several days. Very full and novel results have been obtained by Keeble and Gamble in their valuable work entitled "The Colour Physiology of the Higher Crustacea" (Phil. Trans., vol. 196, pp. 295–388, 1904).

*Armature.*—The prothoracic plate large, occupying the entire length of the segment, with four dorsal glandular setae (*i*, *ii*) and two subdorsal setae (tubercle *v*), a double one, *i.e.*, one with two setae, directly in front of the spiracle, and two separate ones (*vi*, *vii*) at the base of the leg, this arrangement being the same in all the thoracic segments.

The second thoracic is considerably longer than the third thoracic segment, the anterior half forming on each side a distinct swollen, smooth boss, which in the succeeding stage becomes one of the four false spines or "horns"; directly behind on each side of the median line is a tubercle or boss sending off two glandular hairs (*i*, *ii*, Pl. XLII, fig. 1); each boss is at the end of a transverse ridge. The third segment repeats the same characteristics, but the smooth bosses are lower and smaller. It is thus seen that already in this stage the "horns" of this sphingid larva are in no way homologous with the horns of the Ceratocampidae, which are specializations of the first dorsal tubercles (*i*). These bosses or false tubercles become a little more prominent at the end of the stage.

On each abdominal segment one to seven, the four dorsal tubercles (*i*, *ii*), are arranged in a trapezoid, as in nearly all primitive larvae.

On the side is a subdorsal series (*iii*), and directly below the spiracle tubercle *iv*; while in front of each spiracle is tubercle *v*; tubercle *iv* is situated in a line vertically with *iii*, and midway between it and the end of the mid-abdominal legs, *i.e.*, just above the base of each of these legs. On the apodous abdominal segments one and two are tubercles *vi* and *vii* (regarded by Dyar as representing tubercle *v*), which are rather far apart from each other.

The glandular hairs are all of uniform length and shape, being a little stouter than the other setae and enlarged or bulbous at the end. Those of the dorsal series (*i*, *ii*), are much more bulbous at the end than those of the sides (*iii*-*vii*).

There are none on the eighth, ninth, and tenth segments with bulbous tips, the setae there being somewhat acute and only slightly blunt at the end. The suranal plate is triangular, smooth on the surface, and with four glandular setae on each side.

The caudal horn on first hatching of the larva is two-thirds as long as the body, or 2.5 mm. in length. It is cylindrical and slowly tapers to the end, which is forked, each lobe bearing a short, blunt seta, about half to a third as long as the horn is thick; it is blunt and a little swollen at the end (Pl. XLII, fig. 1). The horn is densely covered with microscopic glandular setae which arise from a tubercle, and are broad and forked at the end; occasionally there is one twice as large as the others.

It is worthy of notice that the fourth pair of mid-abdominal legs are remarkably thick, being nearly twice as thick and long as the first pair. Also those of the first pair are smaller than those of the second, and the second than the third. The larger size of the fourth pair is evidently due to their exercise in grasping while the larva rests in the sphinx-like attitude, the body being supported on this and the anal legs. The thoracic legs are very pale vitreous green.

*Coloration:* At about the middle of this stage the oblique pale whitish lines appear; all the granulations are whitish green, paler than the pale green ground color. The seven lines nearly meet on the back, nearly blending with the whitish median line. The four thoracic bosses are whitish. The caudal horn is slightly flesh colored. There are two parallel whitish dorsal lines which extend along the body and include the four bosses, which are also whitish, not yellowish green. There are five transverse wrinkles ("subsegments") on second and third thoracic segments, the bosses being on the second wrinkle.

The larva molted August 12 to 16, 1900. The young larvae either in this or the next stage spins a thread, by which it hangs and assumes the sphinx attitude.

*Stage II.*—Length, 12-15 mm.; width of head, 1½ mm.; length of caudal horn, 2.5 mm. The body is long and slender, the head at first somewhat wider than the body. *The larva has now assumed the fundamental characters of the final stage*, the four thoracic false horns being developed, and the integument of the head and trunk being densely covered with sharp granulations or secondary spinules. The head is pale green, with dense white conical secondary tubercles or spinules of uneven size, two of which on the vertex are slightly larger than the others. The trunk is yellowish green. Prothoracic segment with about twelve uneven conical

tubercles on the front edge of the shield, of which the four dorsal ones—two on each side—are a little larger than those on the sides below.

The false horns of the second and third are now large and high, erect, like a dog's ears, and roughly tuberculated; they are of nearly the same size, but those on the third segment are slightly smaller than the anterior pair. They are not in this stage one-half as long as the segment bearing them, and end in a fine short seta, but the "horns" do not end in a single point, as the accompanying two or three terminal tubercules project up nearly as far as the most distal one. The two little double-headed tubercles (*i* and *ii*), one pair behind each false horn, are minute, like those behind on the abdominal segments, but still somewhat larger. On the abdominal segments (1-7) each of the eight transverse annulets or folds is raised dorsally into a setiferous conical secondary tubercle. The caudal horn is as long as the seventh, eighth, and ninth segments with the suranal plate, all taken collectively, and is densely covered with fine setiferous simple tubercles. The tubercles on the median line of the abdominal segments 1 to 7 now form a white line, as in the fully grown larva.

The two lateral dorsal lines on the two hinder thoracic segments are now indistinct, but the oblique greenish white lines are more distinct. The legs are as in stage I.

*Stage III.*—Described August 21. Length, 15-25 mm.; head,  $2\frac{3}{4}$  mm. in width; length of caudal horn, 3 mm. Now the false horns are higher, and the white median dorsal and seven long lateral oblique lines are whiter and more distinct. The slight yellowish-green ground color of the previous stages has disappeared and the line is uniformly pale green. The head is still wider than the body and rough with projecting white, sharp conical tubercles. The four false horns are now larger than before in proportion to the size of the body, and covered with minute white conical sharp tubercles; they are about one-third as long as the body is thick; those on the third thoracic segment a little smaller than those on the segment in front. The white medio-dorsal line of fine tubercles on the abdominal segments makes a distinct rough serrated line. The seven pairs of oblique white lines are made up of sharp irregular white conical tubercles, each with from one to three points, while the eight transverse ridges are covered with similar tubercles, making a white crest on the edge of each ridge. The spiracles are still pale and inconspicuous in my examples, but in those drawn by Mr. Joutel they are represented as black. The caudal horn has now a yellowish tint.

*Stage IV.*—Length, 18 mm. One molted August 29. It is the same as in the previous stage, but the tubercles are whiter and the lines more marked. The spiracles are now black. It molted again September 8.

*Stage V and last.*—Length, 45-65 mm. Head, a little more than one-half as wide as the body, reddish olive-green, with two faint, paler lines converging on the vertex from each antenna. The surface of the head with fine dark tubercles. The four false horns are about one-third as long as the body is thick. The two on the second thoracic segment are a little more pointed and slender than the two behind, but the four are now of the same length. A dorsal line of small tubercles connects each of the false horns on a side (indicated in stage II), and the two lines meet on the front edge of the second abdominal segment. The caudal horn is of the same color as the thoracic ones, pale at the ends; it is soft and flexible, not stiff and rigid. The ground color of the body is now, in my examples, of a uniform reddish olive, though hardly green. Mr. Joutel's drawing represents the larva as pale whitish green, and I suspect that there is in this species a slight degree of dichromatism. The spiracles are black on each side of the slit or opening. The thoracic legs are now bright red. The suranal plate is convex, with a few fine dark tubercles; it is reddish on the edges. The posterior three-quarters of the anal legs are also reddish-olive. The mid-abdominal legs are olive, of the same hue as the body. The larva began to pupate at Brunswick, Me., September 18. The color of the body when about to transform is of a peculiar rust-red purplish tint."

<sup>a</sup> In a specimen found in Providence, September 24, the ground color is of a peculiar glaucous green, with a pearly tinge; the lines and bands all white, as also the granulations. The tips of the thoracic and of the caudal horns are dark. It is to be observed that this larva, which lives on the elm, is of the same hue as *Nerice bidentata*, while the horns are, like the tubercles of the *Nerice*, tipped with dark. Does this not suggest that the color of the elm leaves, with their dark tipped serrations, have reacted alike on the larvae of the two moths?

It appears from Lt. Col. J. W. Fawcett's description and figure of the larva of *Protoparce maritii* Butler, of South Africa, that there are "paired humps on first and second somites." Judging by his figure, these humps are lower, more rounded, but are situated on the front edge of each segment, as in Ceratomia. We thus have in two quite different genera of Sphinginae this singular mimicry of the thoracic tubercles of Ceratocampine.

*The first larval stage of Ceratomia undulosa*.—(Pl. XXXIV, fig. 5.) Stage I. The larva is long, slender, cylindrical, but widely differs from that of *C. amyntor* in the same period of life in being destitute of the four boss-like rudimentary horns, the segments being in this respect normal. The hinder or fourth pair of mid-abdominal legs are, judging by Mr. Joutef's drawing, even smaller than the third pair, which are much larger than those in front. The body is of an uniform pale whitish flesh color, with no markings.

*Incongruence in the genus Ceratomia*.—*Ceratomia undulosa* seems to be generically distinct from *C. amyntor* in stage I, both as regards the absence of the rudiments of dorsal false horns and in the mid-abdominal legs being smaller than the others, or at least no larger than those of the second pair.

The larva of *C. catalpe* in all its stages, as described and figured by Riley, is also entirely unlike *C. amyntor*, being, after the first molt, smooth bodied, while its markings are very different, the body being without any oblique whitish lines, and in the two last stages the skin is "smooth and velvety." In the second stage the head is smooth and polished, with no traces whatever of thoracic false horns (Rep. U. S. Entomologist, 1882, p. 189).

The larva of *C. hageni* resembles, according to Riley, that of *C. undulosa*; it is marked with oblique yellowish-green lines. The incongruence between the larva of the species now referred to Ceratomia, is striking. It is to be observed that Riley refused to associate either *C. catalpe* or *C. hageni* with *C. amyntor*, but referred them to Sphinx. Certainly *C. amyntor* stands alone, and the pupa and imagoes of the genus Ceratomia as now accepted should be revised.

### VIII. PHYLOGENY OF THE CERATOCAMPINÆ.

The most primitive, generalized genus of the group is Adelocephala, unless it should be found that *Astyli's bellatrix* is still more so. Unfortunately the larva and imago of this form are not obtainable.

That Adelocephala is the stem-form from which the other genera have originated is suggested by the larval armature, the presence in the undetermined Brazilian larva (Pl. XLIX, fig. 4) of quite well developed prothoracic horns, and by the equality in length and shape of the dorsal horns both of the thoracic and abdominal segments.

Already in Syssphinx the armature has undergone a very considerable reduction, showing that it has diverged from the main line of descent.

A decidedly remote side branch, with no annectant form, is Anisota, which notably differs from all the rest of the group in the reversion of the caudal horn to a pair of separate setiferous tubercles. This would seem to be the result of a *per saltum* retrograde mutation—a case of reversal evolution; also the decided reduction in length of all the thoracic horns, except those of the second thoracic segment, is a case of discontinuous evolution by partial atrophy. Correlated with these modifications are certain differences in habits in the case of the species of Anisota, which are gregarious and seem to be avoided by birds, judging by their feeding in exposed situations and by the great number of individuals.

Returning to the main evolutional path of the group, we observe that Eacles is not remotely disconnected from Adelocephala, although in this genus toward the end of larval life, in contrast with the exuberant growth of horns in the earliest stage, there is a reduction in the length of the spines. The pupa is of the type of that of Adelocephala, and in the imago there is not a great difference.

In Citheronia, especially *C. regalis*, we have a return to Adelocephala, with its prothoracic horns and exuberant growth of spines, which are retained through all the stages of larval life. The pupa, however, is more modified and diverges more widely than that of any other genus from the other members of the subfamily, while the moths tend to have fairly well developed maxilla, with which they lap up sweets, and sharp fore wings, anticipating the sphinges in their shape. Which of these five genera gave origin to the ancestor of the Sphingidae is a question. It must seem, however, as if the stem-form was an ally of Adelocephala.

The probable course of phylogenetic development may be expressed by the following diagram, which also indicates the classification of the group:

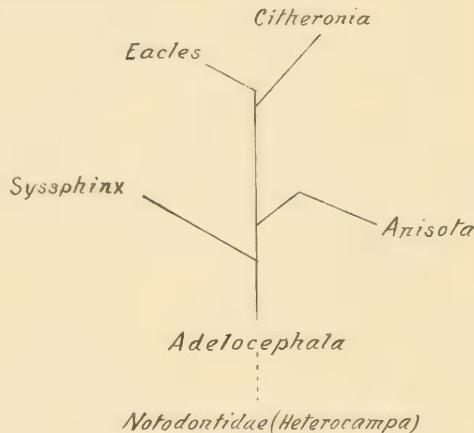


FIG. 2.—Diagram to illustrate the affinities and phylogeny of the Ceratocampinae.

#### IX. ON THE PHYLOGENY OF THE SPHINGIDÆ; THEIR DERIVATION FROM THE CERATOCAMPIDÆ.

In his "Hawk moths of North America" (Bremen, 1886) the late A. R. Grote remarks on the intimate relationship between the Sphingidae and Bombycidae "suggested by the American group of the Ceratocampidae," regarding the latter group as the "remains of an old type and nearer to the hawk moths than any subfamily of the spinners now existing."

In his "Notes in 1887 upon lepidopterous larvae" (Trans. Ent. Soc., London, 1888), Professor Poulton, from a study of the armature of sphingid larya and that of *Aglia tan*, states: "We have therefore an accumulated body of facts which seem to render it certain that the Sphingidae are a specialization of the group of Saturnian Bombycids, and that the following order represents the nearest affinity and is an approach toward the expression of genetic relationship: Sphinx, Acherontia, Smerinthus, Ceratomia, Lophostethus, Aglia, Ceratocampa (Attaeus), Saturnia." He adds: "The imaginal condition of the Sphingidae which come nearest to Aglia, etc., is also strongly in favor of the above arrangement. They alone do not feed in the perfect state, and do not fly in the characteristic manner of other hawk moths; in the strict sense of the word they are *not* hawk moths. Their mode of flight, and especially their rudimentary and unused mouth parts, are further points of affinity to the Saturnians."

It therefore follows that the chief peculiarities of the Sphingidae, as opposed to the main body of Bombycids—the fact that they feed largely and are greatly specialized in relation to flowers—are characters which were absent from their Bombyciform ancestors, and are still absent from Smerinthus, while they have been reacquired comparatively recently in the phyletic history of the majority of Sphingidae.

"The most natural arrangement would be for the Sphingidae to form the end of one special line of Bombycoidæ, the order being the exact reversal of that given above" (p. 573).

In an essay<sup>a</sup> published in 1890, I indorsed Poulton's conclusions, remarking that while the Sphingidae had probably descended from forms like the more generalized Ceratocampidae, there were some points in the imaginal characters which appeared to forbid the idea that they have immediately descended from Aglia. It now appears that this genus does not stand alone, but is closely related to Arsenura, etc., the group Agliina being a South American one, with a single Eurasian genus in the Arctogaeic realm. I may be permitted to quote the view then presented.

"But the origin of the Sphingidae from forms like our modern Ceratocampidae is supported by a fact not mentioned by other observers, i. e., the similarity in shape and the great size of the anal legs of Sphingidae and those of the Ceratocampidae.

"Anyone who will compare the larva of the two groups will be struck with the resemblance. The sphinx-like attitude is also assumed by *Eacles imperialis* while feeding, and, taking together this identity in attitude, the presence of a caudal horn and the general shape of the body, I do not see why the Ceratocampidae may not be regarded as an archaic group from which the Sphingidae may have sprung, while the former may have originated from spined Notodontian larva, such as *Elemaea concinna*, the Notodontians being apparently the most generalized forms of all the Bombycoidæ, and also as regards the larvae, being the most plastic forms; either assuming the greatest variety of ornamentation, or being quite unadorned."

In his excellent monograph of the Sphingidae of America north of Mexico<sup>b</sup> Prof. J. B. Smith divides the family into four groups or subfamilies: Macroglossinae, Charocampinae, Sphinginae, and Smerinthinae, in the descending order, regarding with others the Macroglossinae as the most specialized group, and the Smerinthinae as standing at the foot of the series, having a "small retractile head and obsolete tongue." He considers them as "insects thoroughly bombyciform in habit and appearance, but completely sphingiform in larval and imaginal character." He also briefly suggests more clearly than any previous author, though not in a detailed way, the resemblance of the Smerinthinae to what he calls the Saturniidae, stating that the group Smerinthinae "seems to find closer allies in the Saturniidae through Cressonia to the most typical Smerinthinae."

I have, after a somewhat prolonged study of the Ceratocampidae, compared them with the genera Cressonia, Marumba, and Paonias, and have been greatly interested and surprised to find so many vestigial ceratocampid characters in the larva, pupa, and imago of the Smerinthinae. The result is to prove, at least to my own satisfaction, that the caudal horn is only one of a number of characters which indicate the direct descent of the Sphingidae from the Ceratocampidae, and most probably from the most primitive subfamily, the Ceratocampinae.

The two diagnostic characters which separate the more primitive and generalized Sphingidae from the Ceratocampidae are the position of the tubercle of the spiracular series, or  $r$  of Dyar, in the larva, and the presence of an additional vein (III 2, radius 2) in the forewings of the imago. As stated further on, these appear to be sudden acquisitions which originated during the period when the group diverged from the parent ceratocampid stock. It should be observed that the tubercle  $r$  is of the same shape and structure, the difference between the larva of the two families being in regard to its position.

*Larval features.*—We will now, beginning with the larval characters, give the grounds for our opinion that the Sphingidae have directly descended from the Ceratocampinae.

The young larva (Stage I, Pl. XLII) of *Ceratomia amyntor*, in the shape of the head and proportions of the body, the shape of the suranal plate and anal legs, is the same as in the young of *Eacles imperialis*. I can see no distinctive family characters in the parts of the head and organs of mastication, in the shape of the two divisions of the clypeus; that of the cleft labrum and of the antennae are nearly identical in Eacles and Ceratomia. It is doubtful whether there are diagnostic primary family features in the head and mouth parts of lepidopterous larvae in general,

<sup>a</sup>Notes on some points in the external structure and phylogeny of lepidopterous larvae. Proc. Boston Society Nat. Hist. XXV, May, 1890, p. 100.

<sup>b</sup>Trans. Amer. Ent. Soc. XV, 1888.

whatever may be said of the secondary armature; at least we have not observed any, certainly none of taxonomic value, though this subject has not yet been carefully or extensively examined. The habits of nearly all lepidopterous larvae being the same, we should not expect any decided differences—except in the leaf miners and the more primitive forms, such as Eriocephala (Monog. Bombycine Moths, I, p. 60).

The head in the Smerinthinae genera is conical, the vertex tending to be narrow and somewhat elevated, but in the higher Sphingidae the head becomes round. Now, the conical shape of the head of the Smerinthinae seems to have become directly inherited from the conical shape characteristic of the Ceratocampidae, especially Adelocephala, the most primitive genus of the group.

In the armature the position of the setiferous tubercle *r* directly in front of the spiracle is a trenchant or differential character, and, as Dyar says, it is characteristic of the sphingid larvae. We are able to confirm all he says as to this feature. As we have already stated (p. 31), the freshly hatched larva of *Ceratomia amyntor* absolutely differs in this respect from any larvae of the Saturniides. It should be observed, however, that these primary tubercles disappear after the first molt and that only the freshly hatched young of *Ceratomia amyntor*, and *C. undulosa* have been examined. Provisionally, however—namely, so far as our present knowledge extends—I quite agree with Doctor Dyar as to the significance and value of this group character. The position of the tubercle in the Sphingidae is one apparently which was suddenly acquired, as if by a leap, or "mutation," but as to the cause of the change of position, since in all the great groups of bombycine moths (Saturniides) it is universally situated below the spiracle, while tubercle *ir* is moved up behind the spiracle—we are quite in the dark.

The glandular setae of Ceratomia are like those of certain Notodontidae.

This is a primitive character, not occurring in Ceratocampidae, in which the setae are all acute, nonglandular, or the setae at time of birth are, with the tubercles, converted into large spines. Another feature in smerinthine, but not the "higher" sphingid larvae, is the occurrence of crowded minute secondary tubercles on the integument of the head and trunk, rendering the skin rugose or shagreened. An approach to this is, however, seen in larval Adelocephala and Anisota. Also sphingid larvae have no specialized lateral or submedian spines on the suranal plate, or rough, coarse granulations on the edge of the anal legs. It will be remembered that the head in the smerinthine larvae is subconical, narrowing above, while in the more specialized groups the head is more rounded. This conical shape of the head seems to have been directly inherited from the Ceratocampidae.

A salient feature of the Sphinx larva is the caudal horn; as has been shown by a number of entomologists, and, as we have repeatedly observed, it differs in no respect in its general shape and originally double origin from that of the Ceratocampidae, and seems to be, like the other characters here mentioned, an heirloom from the Ceratocampidae. It appears, then, that, with the exception of the position of the tubercles *ir* and *r*, the larval characters of Sphingidae are such as indicate the direct descent by divergent and saltatory evolution of the group from some primitive ceratocampine form, like Adelocephala.

In the very interesting larva of the South African sphingid, *Lophostethus dumolinii*, we have the unique occurrence of a larva beset with a complete armature of long, rather stout, chitinous spines, those of the dorsal and subdorsal series about or nearly as long as the median caudal horn. Doctor Dyar<sup>a</sup> has thoroughly discussed the armature of this larva and shows that while it has a remarkably ceratocampid-like appearance the tubercle *r* is situated directly in front of the spiracle, a characteristic of its position in those larvae of the sphingids yet known. There are no spines on the first thoracic segment; tubercle *ir* is not represented. The larva, he says, "is a true Sphinx, not more nearly related to the Ceratocampids than any other Sphinx, since it possesses true sphingid tubercles, *ir* above *r* and before the spiracle, not united with *r* as in all the Saturnian phylum. Functionally, indeed, it is a Saturnian like the African Saturnians, with thorn-like tubercles; but the character is evidently adaptational, an irregular hypertrophy

<sup>a</sup> Proc. Ent. Soc., Washington, iv, May 13, 1901, p. 440.

of the tubercles superimposed on the phylogenetic characters of the Sphingidae." The style of coloration, he says, is not sphingid but ceratocampid. "The head and cervical shield are conspicuously striped with black; the anal plates are red, with black borders; the body is green; the spines black, with yellow bases; the foot shields black. A white or yellow bar extends between the second and third spines on the first to seventh abdominal segments."

We would note the fact that Fawcett places this hawk moth in the subfamily Smerinthinae, the most primitive group of the Sphingidae. The pupa has short maxillæ, and a large, short, rounded cremaster.

It is also interesting to note that the armature is very much like that so prevalent in the South African subfamily Bunaïnae, represented by *Gymnais*, *Nudaurelia*, *Bunaea*, etc., and that the caudal horn is not like that of other Sphingidae, especially the Smerinthinae, in being thick, fleshy, and tuberculated, and more or less flexible, but is solid, stiff, chitinous, like the other spines on the body. In this feature do we not see the effects of the dry, peculiar climate of Africa, where there are so many spiny plants and trees? The spines may have arisen after the ancestors of *Lophostethus* had established themselves on the African continent. It should be borne in mind that the South American continent (Neogaea) is apparently the center of origin of the Sphingidae. The same or similar climatic conditions may have influenced the coloration of this larva.

*The pupa.*—When we compare the pupa of *Paonias excaecatus* ♂ with that of *Eacles imperialis* ♂ there will be found to be no salient or diagnostic differences, such as we would expect, to separate the pupa of two great families. The shape of the body is nearly identical; the head of *Paonias* is slightly more conical in front, not so much rounded; but the surface of the integument is covered with fine spinules. The antennæ are the same in width and in the raised joints and pectinations. The maxillæ are of the same shape and length, but wider at base than in *Eacles*; the eyes, epicranium, and elypterus are the same, their surfaces similarly though less rugose, but without any specialized spines. There are in either form no traces of primitive characters such as occur in the more primitive lepidopterous families.

The cremaster in *Paonias* is large and ends in an undivided spine, not forked as in *Eacles* and other ceratocampid pupæ, with the exception of *Citheronia regalis*, in which it is vestigial, and shows signs of an original division. Also the segments of the abdomen are smooth, and segments IX and X are complete in *Paonias*, the sutures not interrupted and obsolete between the scar of the genital opening and that of the vent. This may prove to be a family or diagnostic character. (Pl. LVI, fig. 8a.)

It is to be observed, then, that the pupæ of the Smerinthinae are generalized, and in their head-characters, those which are most fundamental, agree with those of the Ceratocampidae, while in the more variable shape of the terminal abdominal segments and the cremaster there is a departure from the ceratocampid shape.

As we ascend the sphingid series and reach *Phlegethonius* with its enormous tongue case, forming a partly free structure, we have a feature peculiar to the Sphingidae, but as is well known the maxillæ, even in the more specialized Sphingidae, are exposed to great variation, and they may be in the pupa buried between the fore legs on the breast, or if large, form a salient prolongation of the front of the head, as in *Charocampa*.

As regards the habits of the pupa the Sphingidae have retained the subterranean mode of life of their ceratocampid ancestors, in no case known to us spinning a cocoon or lining their subterranean quarters with silk, unless in sporadic cases a few silk threads are spun.

*The imago.*—There are in Sphingidae eleven veins in the fore wings and nine in the hind wings. The most striking and diagnostic character separating the two groups of Sphingidae and Ceratocampidae is the presence in the former group of radius 2 ( $III_2$ ), which arises within the middle of the wing before the end of the discal cell. By the addition of this vein the wing is greatly strengthened on the costal border, which receives the force of the blow during the movements of the wings in flight. This vein is absent in all the genera of Ceratocampinae, but it is generally present in the subfamily of Bunaïnae, where, however, it is a very short, weak vein developed near the apex of the wing. It is absent in *Nudaurelia cytherea* and vestigial in *Sahassa*,

*Cremastochrysalis*, *Melanocera*, and *Cirina*. It is present in ♂ *Cyrtogramma citraria*, but absent in ♀ *C. herilla*. In the Hemileucidae it is usually absent, though present in *Coloradia*. In *Saturniidae* it is wanting, or very short, arising at the apex, and almost vestigial.

It appears, then, that in the Sphingidae this vein, either atrophied or vestigial in the superfamily of *Saturniidae*, has become revived, restored, and strengthened, and functions as one of the important veins in the wing. Its presence is correlated with the narrowness of the whole wing, the acuteness of the apex, and consequent greater strength of the fore wing, adapting the moth for swift, powerful flight. It is to be observed that the bombycine character of but three branches of the so called, or what was formerly the median vein (now, according to Enderlein, medius 3, cubitus 1 and 2), are the same as in the superfamily *Saturniidae*, while the "independent vein" (medius 2) is detached as in the saturniid, but this vein arises nearer medius 3 than medius 1, in this respect differing from the position of this vein in *Ceratocampinae*. The anterior discal vein of the Smerinthinae also differs in its direction from that of the *Ceratocampinae*, being directed inward instead of outward, toward the origin of the hinder discal; this produces a change in the shape of the discal cell, the outer side of the discal cell being parallel with the outer edge of the wing instead of being at right angles to it, as in *Ceratocampinae*. (See Pl. XLIII.)

The forking of the base of the axillary vein also occurs in the *Ceratocampinae*.

The hind wings of the Sphingidae differ from those of *Saturniidae* in those characters which seem to strengthen the wing: the bristle is present, so that both wings are locked together, and an additional axillary ( $A_2$ ) is added, while the subcostal and radius is strengthened by a cross vein arising from near the middle of the discal cell and anastomosing with the subcostal vein (II).

Turning to the head with its appendages, we find that in the primitive Smerinthinae there seem to be no positive diagnostic characters which separate them from the *Ceratocampinae*. The latter, like all the *Saturniidae*, have a large, long, broad, somewhat triangular or seutellate clypeus, extending up and inclosing the antennal foramina. As will be seen by reference to Pl. XXVI, figs. 6, 7, the shape and proportions of the front of the head of the two Smerinthinae genera *Marumba* and *Cressonia* are nearly identical with those of the *Ceratocampinae*, as *Eacles*, etc., except that the head is wider in front in the Sphinges. In the typical Sphinges with long maxillæ the head is much larger, the front more convex, probably owing to the enlarged tongue and its muscles.

The antennae of the typical Sphingidae are, as is well known, of a peculiar prismatic fusiform shape, in the *Macroglossinae* with a terminal hook and no pectinations, but in *Cressonia*, which has evidently retained the vestigial characters of its ceratocampid ancestors, with their broadly pectinated antennæ, the joints are doubly pectinate, or with two pairs to a joint, the pectinations of the anterior pair being a little shorter than those of the basal pair. (Pl. XXXVI, figs. 8, 8a.)

The maxillæ of *Cressonia*, though scarcely "obsolete," as usually stated, being long enough to form a roll when retracted, are but little longer than those of *Eacles* and *Citheronia*. It is a very striking fact that while in the Smerinthinae, which appear to us to be primitive rather than degenerate forms, the maxillæ are so small as to be of little or at least very limited use. It should be carefully observed whether any of the Smerinthinae extend their maxillæ and probe the corollas of flowers, like the typical Sphinges, or if they use the tongue to simply suck the sweets of flowers while resting on their leaves or petals. It has been observed that *Citheronia regalis* will be attracted by and sip the sugar laid as bait on trees. Its tongue is short and feeble, that of *Eacles* a little longer, but in neither case extending as far as the end of the palpi.

When we compare the small size and lack of development and use of the maxillæ of *Cressonia* with those of *Phlegethontius*, which attain a length of over 3 inches (88 mm.), greater than that of the entire body, or that of the South American sphinx (*Macrosila eluctuans*), whose tongue is said by Wallace to be 9½ inches in length,<sup>a</sup> we see that within the limits of a single family an organ like the spiral tongue may by frequent exercise be greatly enlarged and other-

<sup>a</sup>One from tropical Africa, *Macrosila (Xanthopan)*, *morgani*, is 7½ inches long, according to Wallace (Natural Selection, p. 146), though Rothschild and Jordan state that it is about 225 mm., equal to 8 inches. Revision of the Lepidopterous Family Sphingidae, p. 32.

wise modified or specialized, and converted into an enormously long instrument for probing the deep tubular corollas of orchids.

The palpi of Sphingidae are always three-jointed and rather large, while those of the Ceratocampinae have lost the third joint, but in the Aglinae and Bumelinae they are large and often three-jointed.

The legs of Sphingidae are stouter and provided with stout spines, thus differing from those of the Ceratocampidae, which are comparatively weak and unarmed.

The genitals of Sphingidae are in certain genera like those of Ceratocampidae and do not present family distinctions.

We have seen that there is in reality but a slight break or gap between the Ceratocampidae and Sphingidae. Were it not for the changed positions in the larva of tubercle  $\alpha$ , the presence of an additional branch of the radius vein strengthening the costal edge of the fore wing, and of the frenulum, there would be no absolute characters separating the primitive Sphingidae (Smerinthinae, especially Cressonia) from the Ceratocampidae. The larger head, fusiform or prismatic antennae, long maxillæ, narrow, strong wings, stout, spiny legs, and the slight differences in the larva and pupa are simply adaptive characters, due to exercise of the modified organs, the result of the greater activity of the imago in seeking its food, in probing the deep corollas of flowers, and in seeking their mates.

*The revival, restoration, or reacquisition of partially atrophied organs.*—We have observed what a great range in size and adaptability for probing tubular corollas is seen in the development of the maxilla of the Sphingidae, from an almost rudimentary condition in Cressonia to those of the common potato Sphinx (Phlegethonius), and to the enormously long one of the South American Sphinx, and that this is evidently the result of use, and of use-inheritance. This is correlated with the narrow, powerful wings, the large thorax due to the enlarged muscles which raise and lower the wings; with the stout spiny legs, and the large head.

If, as we have attempted to show, by presenting the facts supporting the view that the family of Sphingidae has directly descended from some member of a definite family, i. e., the Ceratocampidae, then we have to deal with instances of a most remarkable phenomenon, that of the revival, restoration, or bringing back to active use, and consequent increased development, of organs or structures which in the ancestral or stem forms have become partially or almost wholly atrophied from disuse. It is universally the case that an organ, once wholly atrophied, never becomes restored or revived so as to function or be of any service in the animal economy. We have seen that in the case of the wings, a branch of the radius vein (III) either entirely atrophied or only vestigial in different groups of Saturnoidea becomes greatly developed in the Sphingidae, thus strengthening the costal edge of the wing. This is a clear case of the restoration or reacquisition by exercise of a structure or organ.

Another case is that of the maxillæ. We should regard those of Cressonia as rudimentary rather than vestigial; but those of the Saturnoidea are, as anyone will acknowledge, vestiges of organs which, in the ancestors of the group, were well developed and of constant use to the insect, as in the Noctuidæ. It follows from this that here we have an instance, and we know of none others on record, of the complete revival or restoration of the muscular, nervous, and mechanical power and activity of a lapsed or nearly atrophied organ.

The infinite variety in the morphology of the mouth-parts of the arthropod phyla does not afford, so far as we are aware, such an instance. It is a nearly universal law that an organ in the last stages of atrophy is never restored to its pristine structural and functional activity.

To suppose that by any process in nature the lost digits of a horse could ever be restored, and that the splint bones could in the descendants of the modern horse in future ages be restored and function as usable toes, seems on the face of it an absurdity; and yet in the useless tongue of the ceratocampid moths we have, unless we are mistaken, an organ which, in the descendants of the group, has become restored in form, structure, and vigor, and so greatly enhanced in development as to form a most striking case of restoration by simple exercise maintained through many generations.

Of course merely rudimentary organs may either remain in an indifferent state, or by change of habit or during metamorphosis become developed and actively function.

#### X. ORIGIN OF THE SYSSPHINGINA AND ALSO THE SYMBOMBYCINA, FROM THE NOTODONTIDÆ.

The family Notodontidae is divisible by larval characters into two groups of subfamilies, characterized by the presence in the larva (1) of simple unisetiferous tubercles (Notodontinae, Heterocampinae, and Cerurinae) and (2) of warts giving rise to several hairs, more than one at least, or to tufts of hairs (Iethyurinae, Pygerinae, and Apatelodinae). It seems evident that each of these two notodontian groups has given origin to a subphylum or superfamily, rather than that the whole family has given rise to one alone, i. e., the Saturniidae. These two groups we would designate as the *Syssphingina* and *Symbombycina*. (See fig. 4, p. 46.)

*Origin of the superfamily Symbombycina*.—I was led to this conclusion by a suggestion thrown out by Doctor Dyar in 1896,<sup>a</sup> and again in 1901,<sup>b</sup> when he shows the relations of the larval armature or warts of the Iethyurinae (Melalophae) to that of the Eupterotidae, Liparidae, Lasiocampidae, etc. In his phylogeny published in 1896, he derives the following five families from the hairy Notodontidae, i. e., Eupterotidae, Lymantriidae (Liparidae), Bombycidae, Lemoniidae, and Lasiocampidae, the last being in his view the latest and most specialized family. Following the suggestion of Mr. Schaus, Doctor Dyar in 1896 included the genus Apatelodes in the Eupterotidae, as also "the other hairy Notodontians, Melalopha, Datana, and Phalera," but afterwards (1901) concluded that this arrangement is contradicted by the form of the eggs (p. 418).

Having been led by Doctor Dyar's suggestions to examine the armature of the hairy notodontians, and to study the head and other characters in abdominal segments 8-10, I am disposed to accept his views as to the origin of hairy larva of the families named from the Notodontidae with multisetiferous warts. Even where the fully fed larva is smooth-bodied, without any hairs or only minute ones, as in *Bombyx mori* and *Endemis visicolora*, as well as the Brahmaeidae, the young larva are born with multisetiferous warts, the setæ being long, fine, and hairlike. In fact my investigations on the larva have led me to observe that there is an extensive group of families which are more or less related to the Bombycidae in the restricted sense. This group, or superfamily, I have called the Symbombycina, the word referring to those families all connected by ties of blood, or kinship, with *Bombyx mori*. The old terms Bombycees, Bombycidae, formerly applied to any moths in which the maxillæ were aborted and consequently from disuse the head became small, the wings less exercised so that one or more veins became atrophied, must now be restricted to this group with its entirely new name, Symbombycina, i. e., all those families affiliated with the Bombycidae, as now restricted to the genus *Bombyx* and its allied genera.

This superfamily has very plainly descended by divergent evolution from the hairy Notodontidae, i. e., the groups Ichthyurinae and Apatelodinae, the former being the more ancestral or primitive one.

On the other hand the Ceratocampidae, Hemileucidae, Saturniidae, and Sphingidae have evidently descended from the smooth-bodied, often more or less humped Notodontidae, i. e., the Notodontinae and Heterocampinae, and this great group I regard as a superfamily. For this group I have proposed the name Syssphingina, because it comprises, besides Sphingidae, the ancestors or primitive forms which gave rise to that highly specialized family, the families mentioned evidently forming a separate subphylum of Lepidoptera.

The steps which led me to consider the Notodontidae as having been the common source of these two great superfamilies may now be stated.

Doctor Dyar has shown the resemblances, or rather close affinity, of the hairy notodontians to the Liparidae, etc., as proved by the nature and situation of the hair-bearing or multi-

<sup>a</sup> Proc. Boston Society Nat. Hist., XXVII, p. 139.

<sup>b</sup> Proc. Ent. Soc. Wash., IV, p. 418.

setose warts. He has also (l. c., Sept., 1896) stated that the warts of *Bombyx mori* in Stage I are "small and degenerate, but true warts of the typical Lasiocampid pattern" (p. 140), and for this reason he associates the Bombycidae with the Eupterotidae, Lemoniidae, Lymantriidae, and Lasiocampidae. Grote<sup>a</sup> had previously (June, 1896) drawn attention to the close resemblance of the warts of Endromis, Stage I, to those of *B. mori*, Stage I, and claimed that both of the families which these genera represent should be removed from the Saturniidae and placed in his superfamily Bombycoides, which, however, contains many families which at present we should exclude from the Symbombycina. In rearing and studying the transformations of *Brahmaea japonica* it was found that the young larva before molting is armed with multisetose warts of the bombycine type, and for this and other reasons should be associated with the Bombycidae, even though there are differences in the venation, especially the cubitus ("median") vein.

It has been throughout a decided mistake to attempt to classify the Lepidoptera on the imaginal characters alone. As abundantly shown by Doctor Dyar and our own recent experience, the larval characters are the more fundamental and decisive; so also the pupal characters, as shown by Doctor Chapman and myself, the egg also bearing as a rule characters which are phylogenetic, showing marks of kinship which can not be overlooked.

The distinguishing characters of the Symbombycina are as follows: The head may be (Bombycidae) small, not prominent, or (Brahmaeidae) fairly large and rather prominent and moderately wide between the eyes; palpi either reduced (Bombycidae) or well developed, 3-jointed, though not reaching beyond the front. The antenna have but a single pair of pectinations to a joint, and these invariably droop, not spreading out laterally as in the Syssphingina, especially the Saturniidae. The maxillæ are usually short and feeble; in *B. mori* atrophied.

The wings vary much in width and shape, while the medio-cubitus ("median") vein is either three or four branched.

The eggs vary greatly in shape in different groups, being flattened oval in Bombycidae, hemispherical in Brahmaeidae, and long cylindrical in Clisiocampa. Their shape in the Eurypterotidae is unknown to us. It should be borne in mind that in the stem-forms the eggs of the Ichthyurinae are hemispherical, with meridional ribs, the surface of the shell being ornamented with polygonal areas.

The larvae all agree in the peculiar shape of the head, a character which has been overlooked by previous authors. It is broad, short, the sides parallel, not rounded, while the epicranial suture is very short compared with that of the Ceratocampidae; also the epicranium is more or less distinctly swollen in front, on each side of the epicranial suture, so that the clypeus is sunken. I have thus far been unable to detect any characters of importance in the larval mouth-appendages. The surface of the head is more or less setose, especially so in Lasiocampidae and Bombycidae. (Pl. XLIV, figs. 2-7.) Besides the head-characters the larva of the different families all agree in the armature. There are among them no larva with unisetiferous tubercles except in the first stage of the stem-form, Ichthyura, but as pointed out by Dyar, there are several (about 6-12) setæ; i. e., warts *i.*, *ii.*, *iii.* are multisetose.

In the Ichthyurinae the first larval stage is noctuiform; after the first or second molt the warts become developed and bear two or several setæ. *The noctuiform characters are crowded back in the phylogeny of the group.*

In the Eurypterotidae, so far as the larvae in this family are known, the caterpillar is densely hairy, the warts multisetose like an arctian larva. Development is direct, and the group does not become highly specialized.

In the first to fourth stages of Brahmaeidae these hairy warts are, on the front and hinder trunk-segments, greatly prolonged into horn-like appendages. In the last stage of Brahmaea the body becomes smooth, unarmed, with mere vestiges of the horns of early larval life; in Endromis and *B. mori* the body is smooth, though the Bombycidae vary in this respect, the body being humped on three segments in Ocinara, and in *Theophila buttoni* abdominal segments 2-7 and 9 bearing each a pair of rather long erect tapering processes.

<sup>a</sup> Die Saturniiden (Nachtpfauenangaben). Mittheilungen aus dem Roemer-museum, Hildesheim, No. 6, Juni, 1896, p. 6.

The shape of the three last abdominal segments, with the anal legs, is characteristic in the Symbombycina. The eighth segment may or may not be humped or bear a horn-like excrescence, but the ninth and tenth segments are well developed, more or less elongated, especially the ninth. In shape and armature these segments widely differ from those in the Syssphingina.

The caudal hump or horn differs from that of the Syssphingina in being soft and fleshy, usually low conical; it is sporadic in distribution, being either present or absent in the Lasiocampidae; apparently absent in the Eurypterotidae.

In *Bombyce mori*,<sup>a</sup> as already stated (p. 20), it arises from a median multisetose wart; present in stage I it is a large conical hump, which is distinctly divided at the end, plainly showing its origin from two separate warts.

In *Brahmaea japonica* in stage I it has lost all traces of its duplex nature owing to the high degree of specialization of the warts in this genus.

The suranal plate is broad, thick, fleshy, either smooth or somewhat rugose (Endromis and Bombycidae), or in *Brahmaea* armed with two horns. In Apatelodes the suranal plate is short, very broad and fleshy, with no armature, and so it is in the Liparidae and Lasiocampidae.

The anal legs differ widely from those of the syssphingine group of families in being soft, fleshy, with no decided chitinous plate or granulations.

The hairy larvae, especially those of the Liparidae and Lasiocampidae, with their conspicuous pencils of hairs have their prototypes in the notodontian genus Apatelodes. In *A. torrefacta* the tufts or pencils arise from minute ill-defined warts. The tuft on abdominal segment 7 arises from two separate areas (not wart-like eminences), one on each side of the median line of the body; those on the eighth segment form a larger area or double group, bearing numerous microscopic papillæ like those all over the body, giving rise to the long secondary hairs, from which the hair-like setæ arise. There are in the full-grown larva no warts, like those present in the young before the first molt. (For the arrangement of the warts in stage I, with figures, see Dyar in Psyche, December, 1895, p. 317.) The pupa varies in the group with the habits of the different generic types. All the larvae are spinners except the Brahmaeidae, in which the pupa is subterranean and with a well-marked cremaster, somewhat reminding one of that of *Eacles imperialis*. The pupa differs, however, from that of Eacles in the head not being bent so far forward, the thorax not being so full and overhanging the head. In this respect the pupa is like the imago, that of the Ceratocampidae having the thorax very full and rounded in front and overhanging the head. The base of the maxillaæ are also much nearer the head-end of the body, while they are about twice as long as in Eacles. The large cremaster reminds one of that of Eacles, but this is evidently a case of convergence; it differs in being constricted at base, beyond much smaller, and ending in two diverging points.

*Phylogeny of the Symbombycina.*—The origin of the group may with a fair degree of certainty be traced back to Ichthyura (Melalopha); at least that genus, especially in the larval stage, appears to be an ancestral type, prophetic of the incoming of more specialized families. It is already as regards the multisetose warts, the secondary setæ, and two double humps and head-characters quite far removed from the less specialized notodontians (Notodontinae) and approximated to the Symbombycina, these being points which I failed to see in preparing the monograph of the group.

For example, the head of Ichthyura in its general shape is very different from that of the Notodontinae and Heterocampinae, being more as in the Lasiocampinae. It is broad; the broad and short epicranium is swollen on each side of the epicranial suture, which is much shorter than in the other notodontians; the clypeus is large. (Pl. XLIV, fig. 2.)

The question arises whether because of these features and the ancestral relation of the group, the Apatelodinae, Dataniinae, and Ichthyurinae should not be removed from the other notodontians and be regarded as collectively forming an independent family. This may ultimately have to be done. But at present we may consider that the notodontians, originally derived from some

<sup>a</sup> I have this spring (1904) raised numbers of *B. mori* from eggs kindly sent me by Dr. L. O. Howard, Entomologist U. S. Department of Agriculture, affording me an abundance of living material for examination.

Thyatira-like noctuid, may have very soon after their establishment become split by divergent evolutionary forces into two groups, one giving rise to the Syssphingina and the other to the Symbombycina. As will be seen by our provisional, tentative, phylogenetic diagram, the more primitive notodontians, i. e., those which at birth are armed with simple setiferous tubercles, gave rise to the Syssphingina.

The other branch or group of Notodontidae, in which the larva on hatching is armed with multisetose warts, gave rise through Ichthyura to the superfamily Symbombycina, which comprises the six families already mentioned.

The Eurypterotidae may have descended from the Apatelodinae. I have not recently studied this group and follow the suggestions of Dyar, who states that *Apatelodes torrefacta* in its first stages distinctly shows the wart characters of the Eurypterotidae.

In the case of the position assigned to the Liparidae (Lymantriidae) and Lasiocampidae, I follow in the main the suggestions of Dyar, having at present nothing new to offer.

From the statements of Grote, and my own observations on the nature and position of the warts of the freshly hatched larva of *Bombyx mori* and an investigation of its later stages, also from an examination of the fully grown larva and the pupa of *Endromis versicolora*, as well as recent studies on *Brahmaea japonica*, I have satisfied myself that the superfamily Symbombycina ends in a group of three specialized families, as represented in the diagram on page 46, which have all apparently descended from some common type. All have multisetose warts in stage I, and lose them after the first molt; all have a caudal horn, while the Brahmaeidae have thoracic and hinder abdominal horns in stages II-IV. The Endromidae and Bombycidae appear to have branched off from a common stem-form, which had four medio-cubital branches. The Bombycidae underwent a process of degeneration; losing a vein, the head becoming reduced in size, the palpi much reduced or absent, the maxilla completely lost, the wings narrow and the power of flight weak, the frenulum absent, the legs being spurless.

The most aberrant and specialized group is the Brahmaeidae, which we shall elsewhere treat of at greater length. *It is to be observed that in these families what are the larval characters of the last stage of hairy notodontians and the families directly related to them have been crowded back during the course of their phylogenetic evolution, and are confined to stage I as the result of the atrophy of the multisetose warts;* the body after the first molt becoming naked and the caudal hump or horn becoming a conspicuous feature, though even this is lost in the final molt of Brahmaea. It is interesting to observe in the ontogeny of *Brahmaea japonica* that before the first molt, besides the ordinary multisetose warts those of the second and third thoracic and the eighth and tenth abdominal segments are greatly elongated and hypertrophied, with the fine spinulose slender setae scattered along the trunk and at the end. These horn-like processes are, however, discarded at the last ecdysis, when the body becomes naked, with mere vestiges of the "horns" left to tell the tale of descent from some form more specialized in stage I than any other of the superfamily yet known.

It should be observed of the families embraced in the Symbombycina, that they are all Asiatic and African forms; i. e., Arctogaeic (chiefly inhabiting the oriental region) and Ethiopian. The Apatelodinae, on the contrary, which we may provisionally regard as the stem form of the Eurypterotidae, is American, the species all being confined to Central and North America, though *A. ardeola* Druce ranges from Panama to the Amazons.

It seems not improbable that the genus originated in Neogaea, gradually passing northward into the eastern Mexican and Atlantic regions of Arctogaea. Whether the ultimate origin of such a great family as the oriental one of the Eupterotidae was in South America seems somewhat problematical.

*Origin of the superfamily Syssphinginæ.*—The proofs of the more or less direct origin of the Ceratocampidae, and especially the genera Adelocephalia and Syssphinx from the more primitive Notodontidae; i. e., those with larval unisetose tubercles, seems very strong. The affinities of the larvae of the two groups are seen in the shape of the head, the long high epicranium, narrowing towards the vertex, the great length of the median suture of the epicranium, and the

comparatively small size of the clypeus, which is not sunken below the level of the epicranium as it is in the Symbombycina (compare XLIV figs. 10, 11, 12, with figs. 13 and 14), the clypeus being still smaller in Adelocephala than in the Heterocampinae.

As regards the armature, that of the notodontian groups Notodontinae and Heterocampinae is closely similar to that of Ceratocampinae. In neither group does more than a single seta arise from a tubercle.

In *Schizura concinna* (fig. 3) the tubercles are solid, chitinous, forming horns; the position of the tubercles is in general much as in Adelocephala, but, as we should expect, the armature is more primitive; tubercle *iii* is near the spiracle, *iv* moved up to a position just below and behind the spiracle; while *v* is quite remote, and *vi* nearly midway between *v* and *vii*. Their position, especially that of *iii*, *iv*, and *v*, is the same in *Heterocampa guttivitta*, stage I, *Sciadonata bilineata*, and presumably in Notodontidae in general. On the other hand in the Ceratocampidae tubercles *iv* and *v* are united. The difference is a family one, but this does not militate against

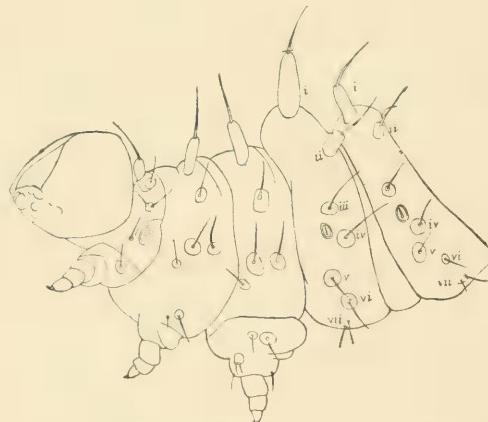


FIG. 3.—Head and first five trunk segments of *Schizura concinna*, showing the arrangement of tubercles *i-vii*.

the derivation by rapid evolution (tachygenesis) of the more specialized or modified Ceratocampinae from the Notodontidae, as it is now a matter of little doubt that evolution from one family or order or class to another may have in most cases at least been effected by a jump or sudden mutation, without a long series of connecting links.

It should also be observed that in the Heterocampinae we have the frequent concurrence of "horns," i. e., of the conversion of tubercles into solid chitinized horn-like processes, bearing a seta at the end. While this may be a sporadic specialization of the dorsal tubercles of stage I of from only one pair (prothoracic in *H. biundata* and *H. unicolor*) to as many as seven (*H. obliqua*) and nine (*H. guttivitta*), yet it is not without significance, as pointing to the evolution of a group like the Ceratocampidae, where they are retained throughout larval life.

Here the question arises whether these antlers and spines of *Heterocampa* and the reduced prothoracic horns of *Materucocampa marthesia* and of *Cerura* may not have been handed down from the genus *Schizura*, or at least that section of it, or the incipient genus represented by *S. concinna*, in which all the segments bear tubercles (*i*), which have become specialized into stout spines.

While the pupa of *Heterocampa* resembles that of *Eacles* in the general shape of the head-region, and in having a forked cremaster, what appears to be a difference of family importance is seen in the two prominent divisions of the lower part of the front of the head, representing the clypeus and labrum.

As regards the imago state, the head, when denuded, of notodontians is much as in Ceratocampinae, the epicranium being triangular. (Compare Pl. XLVIII of this monograph, Pt. I., with Pl. XLIV.) In venation there is a general resemblance, though in the Ceratocampinae there is a loss of two radial veins. Aside from any theory, the Notodontidae proper are closely allied to the Ceratocampidae, differing in characters which, on the whole, are more primitive. The relations of the Saturniidae to the Ceratocampidae will be discussed in a future part of this work; in the diagram (fig. 4) the position assigned to the Hemileucidae is purely tentative and provisional.

It may be objected that the Notodontidae, especially the Heterocampinae, markedly differ from the Ceratocampidae in not possessing the large usually tuberculated suranal plate and the very large anal legs or claspers of that group. It should, however, be observed that in several species of *Heterocampa* the long triangular suranal plate either bears a pair of horns, or at least three pairs of setiferous tubercles. On the other hand the anal legs of these notodontians are much specialized in the direction carried out so remarkably in the Cerurinae. Hence we are led to suppose that the Ceratocampinae sprang from a more generalized form, which on the one hand gave origin to the Ceratocampidae as a whole, and on the other to the existing species of *Heterocampa*, of *Macrurocampa*, and finally of *Cerura* and its allies (Cerurinae).

*Genera, families, etc., artificial groups.*—Any systematist after finishing his work on a group, rises from his task impressed with the difficulty of classifying the genera and species. This embarrassment is, of course, due to the fact that his best efforts are only tentative and provisional attempts to trace out the intricate and bewildering lines or network of affiliated forms. Evolution has gone on by divergent paths, the lines of development forking and reforking from a common origin. Without the aid of the theory of descent, without seeing that everywhere there is a progressive development from the generalized or primitive to the specialized or more recent forms, we should be lost in the fog, or be like sailors without a compass. If we believed that variation was indefinite, fortuitous, without reference to changes in the conditions of life, we should indeed be still sooner lost in a tangled mass of forms, especially in a great group like the Lepidoptera.

To take the present case as an example. The Notodontidae, as compared with the families evolved from it, is a composite or synthetic group, the mother of at least nine families, while from the highest or most specialized family, the Sphingidae, or some unknown group or form allied to it, the Castniidae and the different families of butterflies forming the great superfamily of Papilionides have probably evolved.

So far from being a homogeneous group or family, we have seen that within the limits of what we call the Notodontidae there are two chief groups, one with larvae armed with multisetose warts, and one with larvae provided with tubercles giving rise to a single seta or bristle.

From the beginning of the world's history, for we see it in Cambrian fossils, not only a tendency to, but also an actual and rapid or tachygenic process of modification in different directions has taken place. Just as soon apparently as what we call the Notodontidae arose from probably the small group of Thyatiridae, it began to diverge, to spread out and become adapted to different conditions. While the more normal forms became Notodontidae, there arose, following the line of least resistance, as the result of adaptation to conditions not encountered by other forms, the more aberrant genera *Hyparpax*, *Heterocampa*, and *Macrurocampa*, as well as the Cerurinae.

Meanwhile, in certain forms the tubercles became flat and broad, divided into a number of heads or tubercles, each bearing a hair, and gave rise to the genera *Icthyura*, *Datana*, *Apatelodes*. *Datana* became a specialized closed type, represented by numerous species, while *Icthyura* became the parent or stem-form of five important and in some cases numerically successful families: *Apatelodes*, so far as we can judge, having given origin to the Eurypteridae. If this phylogeny should prove incorrect, there is strong circumstantial evidence that the groups arose from similar though extinct forms. At all events, evolution followed various lines, determined by the various conditions of life, and these lines are older or more recent, shorter or longer, more or less divergent, each type adapted to its particular niche, habitat, or mode of life.

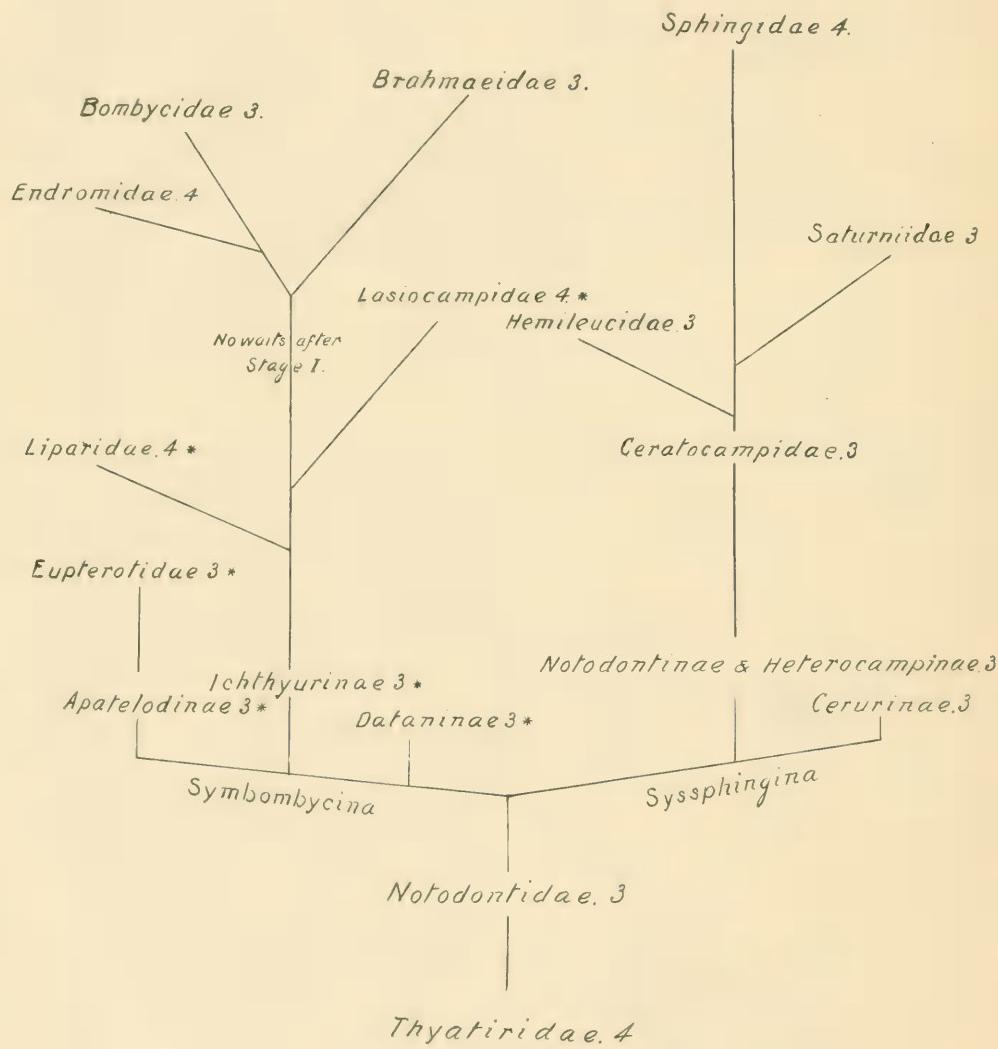


FIG. 4—PHYLOGENY OF THE SYSSPHINGINA AND SYMBOMBYCINA

3, 4 refer to the number of branches of the medio cubital vein; \* indicates the presence of multisetose warts in the larvae.

## XI. OPISTHENOGENESIS, OR THE DEVELOPMENT OF SEGMENTS, MEDIAN TUBERCLES, AND MARKINGS A TERGO.

Weismann, in his suggestive "Studies in the theory of descent" (1876), was the first to discuss the origin of the markings of caterpillars, and to show that in *Delphila hippocephala* the ring-like spots of the larva "first originated on the segment bearing the caudal horn, and were then gradually transferred as secondary spots to the preceding segments" (vol. 1, p. 277).

Afterwards (1881-1890) Eimer<sup>a</sup> showed that in the European wall lizard "a series of markings pass in succession over the body from behind forward, just as one wave follows another, and the anterior ones vanish while new ones appear behind." He speaks of this mode of origin of the markings as the "law of wave-like evolution or law of undulation." In confirmation of this process or law he cites the conclusions of Würtenberger,<sup>b</sup> who had long before (1873) observed that "in ammonites all structural changes show themselves first on the last (the outer) whorl of the shell, such a change in the following generations being pushed farther and farther toward the beginning of the spiral until it prevails in the greater number of the whorls."

Cope, in his "Primary factors of organic evolution" (1896), also shows that in the lizards *Cnemidophorus tessellatus* and *gularis*, the breaking up of the striped coloration into transverse spots begins first at the sacral and lumbar regions: "the confluence of the spots appears there first."

We may cite some examples of this law of growth *a tergo*, or opisthenogenesis, as it might be called, which have fallen under our own observation.

In *Dasylophia anguina*, as shown by the figures in Pl. XXI of this monograph, Pt. I, it will be observed that in stages III, IV, and the last stage, the dark longitudinal lines become on the eighth-tenth abdominal segments broken up into separate isolated dark spots. In the larva before the second molt there are no spots on the ninth and tenth segments. In stage III, however—i. e., after the second change of skin, as stated in my monograph (p. 175)—four black spots now appear on the front part of the suranal plate. In the last stage the reddish spots on the eighth abdominal segment, which are detached from the lateral lines of stages I and II, now become specialized into the two black, comma-like spots, with a linear spot above and beneath; and two, sometimes divided into four, black spots arise on the suranal plate.

It thus appears that in the ontogeny of this species the process of breaking up or origin of the spots from the longitudinal lines takes place on the last three segments of the body.

In *Symmerista albifrons* the same phenomenon occurs. In stage I, as stated in my monograph (p. 180), on each side of the ninth segment, is a large black, comma-shaped spot, the point directed forward and downward, while behind there is a median black dot. After the first molt there arises behind the dorsal hump two instead of one median black spots, and two black spots are added on the side of the body near the base of the anal legs, i. e., two each on the 9th and last segments.

After the second casting of the skin the marking of the last three abdominal segments become specialized; what on the body in front are parallel black and red lines being in this region now represented by separate spots. Thus, as regards the marking, the anterior part of the body remains ornamented with the primitive parallel lines, while the process becomes on the three hinder segments accelerated or specialized. It thus appears that the more advanced or ontogenetically later style of ornamentation originates at the end of the body.

A parallel process takes place with the formation of the caudal horn or hump. Thus in *Symmerista*, *Dasylophia*, and other horned Notodontidae and members of other groups, the eighth abdominal segment is the theater of the process of fusion of the two dorsal tubercles of the first larval stage into a single tubercle or horn; so that this segment appears to be the center of a process of specialization which does not take place on any other segments of the body.

<sup>a</sup> Untersuchungen über das Variieren der Maureidechse. Archiv f. Naturg., 1881. Ueber die Zeichnung der Thiere. Zool. Anzeiger. 1882, 1883, 1884. Organic Evolution. London, 1890.

<sup>b</sup> A new contribution to the zoological proof of the Darwinian theory. Ausland, 1873. Nos. 1, 2, and Studies on the history of the Descent of the Ammonites. Leipzig, 1880. (In German.)

When it does take place, and there is a specialized single tubercle on the first abdominal segment, as in Notodonta, Nerice, and more especially in Hyparpax and Schizura, the process of fusion of two tubercles into a single specialized one, as on abdominal segments 1 and 8, proceeds from behind forward, as it were in waves of translation of the specialized growth force from behind forward.

This may clearly be seen in the figures on Pl. XXIV, showing the development of the single hump in *Hyparpax aurora*. In fig. 1 the dorsal tubercles *i* in stage I are all separated; in fig. 2 those on the eighth abdominal segment have all begun to unite at their bases before they have on the first abdominal segment; they seem to be a little behind at first, though later on the hump on the first segment becomes higher and larger than the caudal horn.

If there were any doubt as to the relative period when the tubercles become fused in Hyparpax, in *Schizura leptinoides* (Pl. XXVI), it is very clearly shown by fig. 1 that the fusion of the two tubercles forming the caudal hump, as we will call it, i. e., that on the eighth abdominal segment, has taken place before any signs of such fusion have appeared in the pair on any of the segments in front.

When the ontogeny of *Nerice bidentata* is worked out, it will be a matter of much interest to observe whether the dorsal humps are formed from behind forward, or whether they appear simultaneously, and thus form an apparent exception to the law of transfer of growth force from behind forwards.

In this connection it might be observed that in the larva of *Schizura unicornis*, in which there is the very unusual occurrence of a pair of short, thick spines on the vertex of the head (Pt. I, Pl. XXVIII, fig. 2, 2a, 2b), these spines do not appear in stage I and not until after the first molt. These spines persist through stages II and III, but after this disappear, not being present in the last two stages. Thus the growth force resulting in the development of the armature of stage I does not reach the head until after the first molt, and then does not persist throughout larval life.

In the ontogeny of the notodontian family, as well as that of Ceratocampidae and Saturniidae, the process of fusion of the two dorsal tubercles always first begins on the eighth abdominal segment.

Opisthenogenesis as regards the markings appears to be of a piece, or somehow connected, with the opisthenogenetic origin in postembryonic development of new segments. In the cestodes and in annelid worms, multiplication of segments occurs between the head region and the extreme end of the body. Thus in *Polygordius*, as stated by Balfour ("A treatise on comparative embryology," 1880, I, pp. 271, 272): "The conversion of the larva into the adult takes place "by the intercalation of a segmented region between a large mouth-bearing portion of the primitive body and a small anus-bearing portion."

This region in the larval or early stages of worms and more primitive arthropods is the "budding zone" of embryologists. While at the outset, in the beginning of embryonic life the head region is the first to be formed and the trunk segments arise later, as in the trochosphere of worms, and the protaspis of trilobites and of merostomes; a third portion arising from the budding zone, or seat of rapid cell-formation, appears to be a secondary or inherited region, due to the postembryonic acquisition of new characters (certain trunk segments and their appendages) in many segmented or polymerous animals, i. e., those which have passed beyond the trochozoön stage or type.

Prof. E. B. Wilson<sup>a</sup> has clearly stated the nature, now so well known, of the growth processes involved in the interpolation at the growing point or budding zone of new segments. In *Polygordius*, after the trochosphere has been formed and when it is about to enter on the adult stages, the segments are formed successively, those in front being the oldest, "while new segments are continually in process of formation, one after another at the growing point." This, he says, is "a typical case of apical or unipolar growth." It is what we would call opisthenogenetic growth.

<sup>a</sup>Some problems of annelid morphology. Biological lectures delivered at the marine biological laboratory at Woods Hole. 1891. p. 61. See also A. D. Mead. The early development of marine annelids. Journal of morphology, XIII. May, 1897. p. 227-326.

Professor Whitman<sup>a</sup> has shown that in the leech the internal tissues (mesoblast) of the budding zone are arranged in two widely separated lateral bands, which, to quote Wilson's exposition, "as the trunk grows older widen out and grow together along the median line, ultimately giving rise to muscles, blood vessels, excretory organs, reproductive organs, etc." Now, if this is the case with the more important tissues, why in caterpillars as well as in lizards may not this opisthenogenetic mode of growth also involve the arrangement and distribution of the pigment masses of the integument?

Without entering into the mode of development of the germ bands, which are behind completely separate, gradually becoming united in front, resulting in their union or concrecence, we would make the suggestion that it may be the initial cause or at least in some way connected with the breaking up of the longitudinal stripes of the body, and their transformation into spots at or near the budding zone of their polymerous or polypodous (*Peripatus-like*) ancestors.

In the trilobites, *Limulus*, and diplopods, the new segments after embryonic life are interpolated between the penultimate and anal or last segment of the body, and it is from this region in certain lepidopterous larvae that the transformation of longitudinal stripes into spots takes place. The question next arises whether there is any connection between the opisthenogenetic origin of the markings of lizards and that of caterpillars. The fact now well established by embryologists that the phenomena of concrecence occurs not only in fishes but in *Amphibia* and reptiles, would suggest that the cause of the transformation of longitudinal stripes into spots on the lumbar and sacral regions of lizards is the result of the same specializing growth force. It may, perhaps, be regarded as a surviving remnant of the segment-forming force, which has affected the pigment bands in a manner identical in the vertebrates and insects. This transformation of stripes into spots, and the fusion of two dorsal tubercles into a median one may be then the sign of some latent or surviving amount of force concerned in the origin and formation of segments, which crops out in the larval stages of insects and in young lizards, resulting in this opisthenogenetic mode of origin of spots from bands.

In this connection it will be of interest to quote some observations of Mr. Abbott H. Thayer,<sup>b</sup> which bear on this subject:

The next thing to be pointed out is that the general tendency of birds to wear longitudinal markings forward, and transverse ones aft, is an important factor of protection, especially in the case of the pheasants and peacocks, among whom this arrangement is very highly developed. Any one who has tried to catch a snake in the grass will see at a glance why nature tries to direct an enemy's attention behind the animal he is hunting. The snake forever proves to be farther on. It is hard to set one's foot far enough ahead as he moves, just as a wing shot tends to shoot behind. Now, nature realizing this, offers the enemy the utmost inducement to strike too far back. The strong crossbars of the *Reeve* or the copper pheasant, while visually they cut the tail to pieces when it is still, are, as with the peacock, by far the most visible part of the bird as soon as he moves. The reason of this is that in forward motion the longitudinal markings scarcely show, while the transverse ones become conspicuous. To prove this, any reader has only to blacken a few points an inch or so apart on a white cord, and then move the cord longitudinally, drawn tight across some aperture a few yards away, the cord being only visible when it crosses the aperture. He will see that its motion is distinguishable much farther off when the spots are in sight than when the unmarked cord is passing. The spots correspond to the tail marks of the pheasant, and the cord when it is not spotted represents the bird's longitudinal markings, i. e., his body markings.

## XII. THE SUPERFAMILY SYSSPHINGINA.

Having shown what few and really slight absolute characters separate the Sphingidae from the Ceratocampidae; that the two groups are members of a single phylum or subphylum, i. e., having evidently all descended from a common stem form, I would suggest that these facts, proving blood relationship and community of origin, be emphasized by uniting the Sphingidae (or *Sphingoidea* of Dyar) with the families grouped under the superfamily *Saturnoidea* (*Saturniides* of Grote). They may be designated as the *Syssphingina*, this name indicating that the super-

<sup>a</sup> The embryology of Clepsine. Quart. Journ. Mier. Sc. XVIII. 1878. Journal of Morphology, Boston. 1887. I am indebted to Prof. A. D. Mead for calling my attention to the concrecence process in this connection.

<sup>b</sup> Trans. Entomological Soc. London, 1903, p. 569.

family is a composite or synthetic one, embracing forms both leading up to and including the Sphingidae, all bound together by genetic ties. As there are already too many modifications of the names Sphingidae and Bombycidae, we venture to hope that the name we here propose may be accepted by entomologists. For all the syssphingine families, below Sphingidae, I propose the name *Protopsphingina*.

### XIII. ORIGIN OF THE SYSSPHINGINA BY BOTH CONTINUOUS AND DISCONTINUOUS EVOLUTION.

The results of our studies have taught us that two modes of evolution have been at work in the origin of the family of Sphingidae. First, there was, due to a change of habits, a gradual, continuous process of progressive modification of the small-headed, short-tongued, thick-bodied, sluggish, or nearly flightless Saturniides by way of the Ceratocampina into a Cressonia-like form. This process of change and adaptation to new conditions of life went on for perhaps many centuries or thousands of generations. At length there was a sudden acceleration or revival of growth and development in those partly atrophied organs like the maxillæ, etc., which became restored to the functions enjoyed by the more active ancestors of the saturnian subphylum, and at a critical period, after one consisting of long preparatory but slight changes, a *per saltum* movement or leap occurred, and as the result of this rapid assumption of a new character, which we call an aberration, sport, or mutation, the tubercle *r* of the larvae became shifted from its position in the ceratocampid larvae to what it is in Cressonia, Ceratomia, and the other Sphingida thus far examined, and there also appeared an additional radial vein.

This has been the case with the origin of the genera not only of this group, but this process of frequent rapid evolution takes place in the organic world in general. An example is the differences between Adelocephalia and Anisota, the larvae of the latter genus differing so remarkably from those of the stem-form in the return to the primitive separate tubercles *ii* of the eighth abdominal segment and the reduction in the armature, that only a single pair of thoracic horns are left.

Doctor Dyar<sup>6</sup> has called attention to the discontinuous evolution of a wart bearing hairs from a simple setiferous tubercle, stating that "we do not find a series of intergrading forms between the single-haired tubercle and the many-haired wart, though both may occur in different genera of the same family." The wart-like tubercles which characterize the Saturniidae are apparently suddenly produced characters; also the peculiar branched tubercle spines of the larval Hemileucidae, and certainly the lateral eversible glands which are peculiar to and diagnostic of that family. In fact the fusion of the two tubercles *i* on the eighth abdominal segment of the Syssphingina is a case of more or less sudden or rapid evolution. Thus the discovery that Bombycidae (*Bombyx mori*), Brahmaeidae, and *Endromis versicolora* (Endromidae) all have in the first larval stage warts bearing several hairs proves that they belong to a different phylum from the Syssphingina and should be associated with what we would call *Symbombycina*, including the Eupterotidae, Lasiocampidae, and Liparidae, these families, perhaps, having arisen from the notodontian groups Apatelodinae and Ichthyurinae (Megalophinae).

We hence infer that those absolute characters which distinguish or are diagnostic of lepidopterous families, however slight or trivial in themselves, are sudden acquisitions, due perhaps to comparatively sudden changes in the conditions of life, involving new needs, the formation of new habits, different food plants, etc., or some unknown stimulus. If this be the case, then the different family groups, as well as generic groups in the Lepidoptera, have arisen as sudden departures or changes or divergent steps in the course of what otherwise would be a slow, evenly graduated process of progressive development. If this is the case with Lepidoptera so it is in other orders of insects and other arthropodous phyla, and, indeed, throughout the organic world. For example, the birds with more or less suddenness diverged from the reptilian line of descent; mammals with two condyles originated by a process of rapid evolution from reptiles with but one condyle, and so on.

<sup>6</sup> Annals N. Y. Acad. Sc., viii, May, 1894, p. 196.

If we realized how arbitrary our zoological classifications are, especially the categories we call species, genera, families, and orders; if we could erase from our books and from our minds these artificial pigeonholes into which groups of individuals are thrown, and could divest ourselves of the prejudices resulting from our often untimely and hasty attempts to—without adequate knowledge of the morphology, ontogeny, and life conditions of organisms—frame our ephemeral classifications, we should realize that the secular growth of organic forms, to which we give the name of evolution, is all of a piece with the causes, modes, and results of growth of any individual. What we call primitive generalized forms and specialized forms are merely such stages as we happen to have discovered, or (taking into account the fossil forms) fragments of defective series of forms in process of evolution. Could we see the whole series arranged in the order of their evolution we should realize that in the creation of any phylum or group of blood relations the phylogenetic stages or steps are in the long run, or throughout the whole course of evolution, the result of a process of gradual, slow, secular modifications, with accumulated phases, which appear to us as sports or mutations, and to which process we give the name of discontinuous evolution. There is not an uninterrupted, progressive, ascending series, but there are frequent pauses and backward steps or reversions. Evolution has gone on both by progressive and by discontinuous steps as well as by atrophy. There are often no intermediate forms or stages. Rapid or saltatorial evolution may be compared with the sudden acquisition of characters seen at the time of molting in insects, crustacea, etc.

These phases or aberrations, often forming side branches of the phylogenetic tree or sudden departures from the main stem or trunk, branches which often are the result of evolution by atrophy, become bent downward and backward, as in Saturnides, the bombyciform types of other lepidopterous families, or as in ecto- or endo-parasites of other orders, classes, and phyla. They are so frequent that we must consider them as the necessary and normal or natural results of changes in the environment, leading to change of habit, station, food, and means of locomotion, the final result being adaptation to certain niches, corners, stations, and hosts, where normal types would be unable to exist.

#### XIV. THE GEOGRAPHICAL DISTRIBUTION OF THE CERATOCAMPINÆ.

(Fig. 6 on p. 62; also maps I to IX.)

This subfamily is entirely confined to the western hemisphere, and practically to the tropical and subtropical belt of the two Americas.

The center of origin was most probably the region extending from Brazil to the Isthmus of Panama. At present the group extends over the greater part of tropical and subtropical South America or the Brazilian subregion of Wallace. Several species pass south of this region, as limited by him, into Paraguay and the valley of the La Plata in the Argentine Republic. On the other hand none has yet been detected in the region of the headwaters of the Amazon, nor in Bolivia or in eastern Peru, and none have been recorded from Venezuela and the West Indies or Antillean subregion; one species of *Adelocepha* (*A. columbi*), however, is recorded from Colombia and *Citheronia eminens* from Loja, Ecuador. While the absence of any other forms in these countries may be simply due to lack of extended exploration, it is quite the reverse with the ceratocampinine fauna of Central America.

In its general characteristics the Central American fauna repeats that of the Brazilian subregion, as will be seen by the following lists. The greater number of Central American species inhabit the tropical belt along the eastern coast and on the Pacific coast south of north latitude 20°, and a few occur on the temperate plateau of the region about the City of Mexico, but none have yet been found in the dry regions to the north and northwest.

## SPECIES INHABITING THE BRAZILIAN SUBREGION.

Adelocephala anthoniilis.	Eacles imperialis.
Adelocephala wardi.	Eacles eminens (Loja, Ecuador).
Adelocephala tristygma.	Citheronia princeps.
Adelocephala arpi.	Citheronia principalis.
Adelocephala fallax.	Citheronia laocoon (ixion).
Adelocephala subangulata.	Citheronia phoronea.
Adelocephala boisduvalii.	Citheronia aroa, var. of phoronea (Venezuela).
Adelocephala cadmus.	Citheronia ducalis.
Adelocephala leucostygma.	Citheronia caecius.
Adelocephala crocata.	Citheronia brissotii.
Adelocephala argyraeacantha (Paraguay).	Citheronia leoma (Paraguay and Uruguay).
Adelocephala jucunda.	Citheronia magnifica (Mexico to Paraguay).
Adelocephala brevis.	Citheronia suffusa (Linnaeus, ——).
Adelocephala leucantha.	Citheronia vogleri (Cordova, Argentina).
Adelocephala janeira.	Syssphinx molina.
Adelocephala invalida.	Syssphinx ? basirei.
Adelocephala columbia (Colombia).	? Anisota walkeri.
Adelocephala acuta (Venezuela).	? Anisota bilineata (Uruguay).
Crinodes bellatrix.	

## SPECIES INHABITING CENTRAL AMERICA (MEXICO)

Adelocephala jason.	Citheronia mexicana.
Adelocephala isias.	Citheronia magnifica.
Adelocephala albolineata.	Citheronia splendens.
Adelocephala leucostygma.	Citheronia azteca.
Adelocephala hegei.	Citheronia aroa (var. ? of phoronea).
Adelocephala boisduvalii.	Anisota suprema.
Adelocephala quadrilineata.	Anisota dissimilis.
Eacles imperialis.	Anisota assimilis.
Eacles ormondei.	Syssphinx molina.
Eacles masoni.	

## SPECIES INHABITING AMERICA NORTH OF MEXICO.

Adelocephala bicolor.	Anisota virginianensis.
Adelocephala bisecta.	Anisota stigma.
Adelocephala albolineata.	Anisota consularis.
Adelocephala heiligbrodtii.	Anisota senatoria.
Adelocephala quadrilineata.	Anisota rubricunda.
Adelocephala isias.	Citheronia regalis.
Eacles imperialis.	Citheronia sepuleralis.

In the Arctogeic realm the group is chiefly confined to the eastern half of the Mexican (Sonoran) region, i. e., east of the one hundredth meridian, two species (*Adelocephala heiligbrodtii* and *A. isias*), extending from central Texas, in the valley of the Colorado River, westward into New Mexico and Arizona, probably the region drained by the upper Gila River, i. e., in those hot extensions of the Lower Austral life-zone which pass up the upper Pecos and Rio Grande valleys to about latitude 33°.

These are the only species of the subfamily which have yet been detected west of about the one hundredth meridian, and they are evidently migrants from the Gulf region of Texas. The group, then, within the limits of the North American portion of the Arctogeic realm is confined to the Austroriparian provinces (Lower Austral of Merriam) and also the Appalachian (Upper Austral of Merriam) and upper Appalachian or Canadian province (transition of Merriam), while a few forms (*Anisota rubricunda* and *virginianensis*) cross into the Boreal province, these two species occurring at Franconia, N. H., which rises into that zone.

It is worthy of note that with but two exceptions (*A. heiligbrodtii* and *A. isias*) none of the group occur in America north of Mexico west of the one hundredth meridian, the Rocky Mountain region and the Pacific coast being destitute of any of the group.

*Routes of secular migration.*<sup>a</sup>—Passing from South into Central America by the Isthmus of Panama the species gradually peopled each coast, though more prevalent along the Gulf of Mexico; thence passing along the tropical belt of Texas. A few of the more hardy forms, as those of *Anisota*, *Citheronia*, and *Eacles*, became adapted to or originated in the valley of the Mississippi and the Atlantic coast region, two *Anisotae* finally reaching the region around the Bay of Fundy and the St. Lawrence Valley as far down as Quebec.

Perhaps as late an arrival in the Appalachian province as any of the group was *Adelocephala bisecta*, whose range in the United States is so far as yet known restricted to the warmer parts of Texas and to the valleys of the Mississippi and Ohio, not perhaps having yet reached the Atlantic coast or the region east of the Alleghanies.

Although the Ceratocampidae is a more primitive group than the Saturniidae, the question arises whether they did not pass from Neogaea into Arctogaea long after the latter. That they did is indicated by the wide distribution of the Saturniidae in North America and in fact throughout tropical and temperate Arctogaea. For example, in North America the species of *Samia* must have occupied the continent, for the genus is represented throughout its width from the Atlantic to the Pacific. The species may not have become differentiated until the present climatic features of North America were established. This is indicated by the fact that *Samia cecropia* appears to be the ancestral species, which, as it spread west, gave off the form (*S. glomerii*) adapted to the Rocky Mountain and Great Basin region, the boreal form, *S. columbia*, and finally the Pacific coast form, *S. californica*. *Adelocephala bisecta* and perhaps *A. bicolor* may not have entered America north of Texas until after the glacial period had passed away.

*Neogaea the ancestral home of the group.*—From the foregoing facts it will be seen that the original source of the Arctogaeic forms was Neogaea, and probably that the group originated in the Brazilian subregion. It is here that the most primitive species of Adelocephala occur, as also those of Citheronia, both of the genera being richest in species in the forest region of tropical eastern South America. The genus Syssphinx (and Crinodes, if it be a member of this family) is wholly confined to the Neogaeic realm.

*Geological date of the secular migration into Arctogaea.*—Here we shall have to follow the clew discovered by the vertebrate paleontologists. It is probable that the group was at first confined to the South American continent, not passing northward into Central America until the elevation of the Isthmus of Panama at the end of the Miocene Tertiary. This would indicate that the Ceratocampidae and the family of Notodontidae, from which the former originated, probably date back to the beginning at least of the Miocene Tertiary.

## XV. THE FORE-TIBIAL SPUR OR EPIPHYSIS.

(Pl. XXXVI, figs. 12-24.)

This movable appendage arises from near the base and is articulated to the inside of the tibia of the fore legs. It is the tibial epiphysis of Smith, the "schielenplatte" of Dahl, "schielenblättchen" of Kathariner, and the "spur of the fore tibia" of Rothschild and Jordan. It is well developed in the Ceratocampinae. It has the same general shape and size as in the Sphingidae, in which it universally occurs. Rothschild and Jordan<sup>b</sup> stating that it is "never absent." It is, as stated by Speyer<sup>c</sup> and afterwards by Smith<sup>d</sup> and later by Kathariner, present in the Papilionidae and Hesperiidae and "all Heterocera," except the Hepialidae and, according to Rothschild

<sup>a</sup> We propose the term "secular migration" for the slow migratory movements of organisms extending through one or more geological periods. Seasonal migrations may be applied to those annual migrations of animals which take place in spring and autumn.

<sup>b</sup> Rothschild and Jordan, A Revision of the lepidopterous Family Sphingidae. Novitates Zoologicae, IX, Suppl. 1903.

<sup>c</sup> Isis. 1843, III, p. 161, figures.

<sup>d</sup> J. B. Smith, Bull. Brooklyn Ent. Club., VII, p. 69, Sept., 1884.

and Jordan, the Chalcosiidae. While the statement is made that all the Lepidoptera below the more primitive butterflies possess this appendage, the above-named families excepted, it will be interesting to ascertain whether there may not be here and there cases of its absence in scattered genera, and perhaps subfamilies, of the moths.

Kathariner<sup>a</sup> has recently published an excellent article, for the first time describing the structure and fine anatomy of this appendage in *Acherontia atropos*, *Deilephila elpenor*, and two species of *Sphinx* (*S. convolvuli* and *S. ligustris*).

While, as he says, there is no convincing proof of its being a scent structure, Kathariner inclines to the opinion of Oudemans<sup>b</sup> that it may be a scent organ. The objection to this view is that in the microscopic sections made and figured by Kathariner these are no traces of specialized cells like what have been found by Deegener<sup>c</sup> in great numbers in the hypertrophied hind tibia of *Hippialus hectus*, there being little doubt but that these highly modified hind legs of this genus are true scent organs. In the tibial spurs examined by Kathariner there are no specialized cells besides the matrix or hypodermal layer of the integument, which is, however, folded on the anterior surface of the appendage, and consists of high cylinder cells with granular protoplasm and large elongated nuclei, such as Dahl<sup>d</sup> discovered in sections of the sole of the feet of locusts, and which secretes a glutinous fluid. Whether these cylinder-cells secrete an odorous fluid is problematical.

Dahl has suggested that these appendages may be adapted for cleansing the antennae, being analogous to the spurs on the limbs of other insects, especially the Hymenoptera. In accordance with this explanation Dahl affirms that the fore-tibial spur is wanting in most butterflies with a well-developed antennal knob, and is vestigial in many moths with strongly pectinated antennae. That this appendage is in any way comb-like has never occurred to us, since in the sysphingine moths, as also in the saturnioids, the edges are smooth and unarmed with sete coarse enough to act as the teeth of a comb. We have found these spurs as well developed in the male of *Telegonus polyphemus* as in the Ceratocampidae or Sphingidae; in *Catigula japonica* ♂ the spurs are long and narrow, but in the ♀ only one-half as long and very narrow; in this sex it varies in size and width, some being half as long as others, i. e., one-quarter as wide. In the female of *Sysphingia molina*, however, the spurs are as large as in the male. Speyer states that in the female of certain moths the spur is atrophied. The naked inner side of that of *Telegonus*, and presumably in moths generally, is covered with a dense growth of very fine, stiff microscopic setae, which are short, sharp, and of even length. (See also Kathariner, figs. 4 and 5.) The function of this minute growth seems problematical. In the fore tibia of *Adelocophala hoegei*, the hair-scales are parted so as to expose the spur, the outer side of which is naked, though clothed with a microscopic pile, the edges of the spur being densely scaled.

An objection to the odoriferous nature of these spurs is the fact that in the Sphingidae, where they are so well developed, there occur, though not all in the same species, three kinds of what appear to be, according to Rothschild and Jordan, undoubted scent organs. These authors regard this appendage as homologous with the proximal spur of the hind tibia, but do not give an opinion as to its function. Its use will have to be determined by careful observation. Its large size and more complete development in the male shows that it somehow shares in the movements of the limbs of the forms possessing it. We have never observed any decided signs of these spurs having been put to any use, such as the loss by friction of the scales clothing the outside and edges.

The great size of the fore tibial spurs in *Cithronia separalis* is worthy of note; this species is much more active than *C. regalis*, being not infrequently attracted by electric lights.

In the Ceratocampinae this spur seems in some genera to afford good specific characters, but it is of little practical use in separating either genera or families.

<sup>a</sup> Das Schienenblättchen der Schwärmer. Illustr. Zeits. Ent. IV, Nos. 8, 11. 1899.

<sup>b</sup> Die Niederländische Insekten. 1897. IV, Nos. 8, 11.

<sup>c</sup> Das Duftorganen von Hippialus hectus L. Zeits. wissen. Zool. LXXI, 1902, pp. 276-295.

<sup>d</sup> Beiträge zur Kenntniss des Baues und der Funktionen der Insektenbeine. 1884.

The spurs differ very considerably in the different species of Adelocephala; in *A. montezuma* and *A. subangulata* the spurs are long and wide; in the former species about one-half as wide as long; in *A. subangulata* not quite so wide.

In *A. bicolor* and *A. abbolinata* the spurs are of the shape of those in Syssphinx and Anisota, being narrow and sharp, lanceolate oval. In *Anisota virginiana* they are one-half as long as the tibia, and very blunt at the end. They are also obtuse in *A. stigma*, but differ in shape. In *A. sonatoria* they are narrow, acute, and over one-half as long as the tibia. In *A. rubricunda* they are a little over one-half as long and differ in shape. It thus appears in the genus Anisota to afford specific differences.

In *Eacles imperialis* (Pl. XXXVI, figs. 21, 21a) the spur is remarkably broad and short, being nearly as broad as long, and one half as long as the very short fore tibia.

In *Citheronia regalis* they are much smaller and narrower, but in *C. sepulcralis*, in which the tibia is much longer than in *C. regalis*, the spurs are also large and long; they are thus, like the tibiae, generically different from those of *C. regalis*. It thus appears that the length of the spur accords with and is conditioned by that of the tibia.

#### XVI. THE NOMENCLATURE OF THE VEINS OF THE LEPIDOPTERA.

In Part I of this monograph (p. 84) we adopted Spuler's nomenclature, assuming that he was correct in supposing with Müller, Brauer, Redtedbacher, and Haase that the costa is only a thickening of the edge of the wing, and not a vein having a trachea for its origin. This view was weakened by Chapman's<sup>a</sup> discovery of a marginal vein, which he claims is a normal constituent of all lepidopterous wings, a marginal trachea "occurring during the development of the wing, and often to be discovered in the perfect wing," where it exists as a hollow tube, and carrying like the other veins sensory hairs or bristles.

The whole question as to whether the costa represents or contains a true vein has now finally been set at rest by the investigations of Dr. G. Enderlein,<sup>b</sup> who conclusively and very clearly proves that the costal edge of the wing is in the pupa state supplied by a branch of the radial trachea, as shown in his figure.

Indeed, it appears from a quotation from Speyer (1870) that that lepidopterist observed in a great number of Heterocera, and also in the Phryganeide, the costal vein, "with a very clear lumen, sometimes the strongest vein of the whole wing." Enderlein adds that in certain stages of Heterocera, as *Sphinga pinastri*, it is the "strongest tracheal branch of the wing." Spuler's failure to detect the costal vein was, remarks Enderlein, due to his not following far enough into the interior of the body of the pupa to where it branches off from the main tracheal radial trunk.

Enderlein clearly shows that the veins of each wing belongs to two genetically entirely different systems, which he designates as the radial wing-trunk and the median wing-trunk. His scheme we quote, adding the numbers in Roman numerals in a separate column.

SCHEME OF THE FORE WING OF A LEPIDOPTER.

Radial trunk	Costa	1 branch	(r)	I
	Subcosta	1 branch	(sc)	II
	Radius	5 branches	(r <sub>1</sub> , r <sub>2</sub> , r <sub>3</sub> , r <sub>4</sub> , r <sub>5</sub> )	III
	Media	3 branches	(m <sub>1</sub> , m <sub>2</sub> , m <sub>3</sub> )	IV
Median trunk	Cubitus	2 branches	(cu <sub>1</sub> , cu <sub>2</sub> )	V
	Analis	1-2 branches (atrophied)	(a <sub>1</sub> , a <sub>2</sub> )	VI
	1 Axillaris	1 branch	(ax <sub>1</sub> )	VII
	(2 Axillaris)	1-3 branches (branches atrophied)	(ax <sub>2</sub> )	VIII

Enderlein shows that the discocellular veinlets, i. e., the hitherto supposed two veins closing the discal cell are formed by one or two veinlets arising from the cubital 1 (not from the median, as suggested by Grote).

<sup>a</sup> On some wing structures in Lepidoptera, London, 1901.

<sup>b</sup> Eine einseitige Hemmungsbildung bei 1901. Telea polyphemus von ontogenetischen Standpunkt. Zool. Jahrb. Arth. für Anat. Bd. xvi, Jena, 1902.

The subcostal vein of the hind wings unites with the first radial branch to form a single vein ( $sc + r_1$ ). The short spur from the subcostal of the hind wings is shown by Enderlein to be the costal vein. I may say that I had supposed that this short spur might possibly be the costal, but Enderlein has now proved it to be such. All the cross veins, according to Enderlein, morphologically (genetically) should be regarded as longitudinal veins. He also shows that the enlargement of the wing takes place onto- and phylogenetically chiefly in the middle zone of the pupal or rudimentary wing.

The numbering of the veins, then, in this and the following parts of this monograph will be according to the system of Redtenbacher, Comstock, and Needham as modified by Enderlein, and it is to be hoped that this system will be generally adopted by lepidopterists.

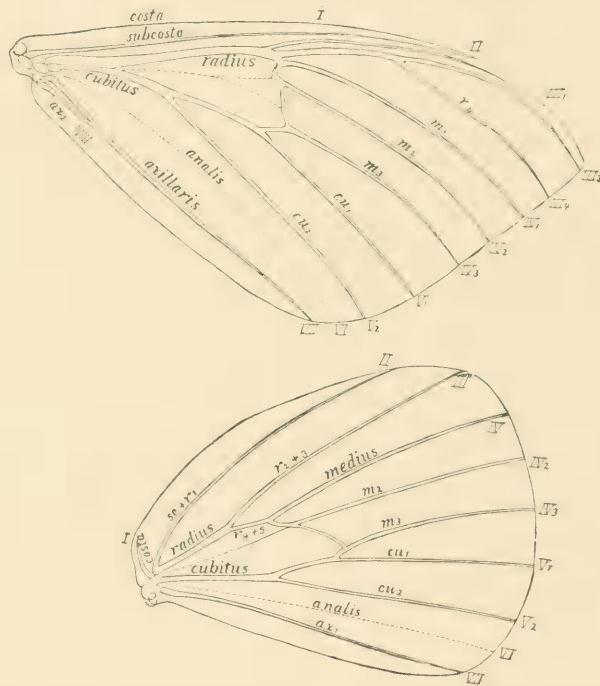


Fig. 5. Nomenclature and numbering of the veins of the fore and hind wings of *Eacles imperialis*.

XVII. CLASSIFICATION AND LIFE HISTORIES OF THE CERATOCAMPINÆ.

### Family CERATOCAMPIDÆ Harris (enlarged).

*Saturniidae*, auct. in part.

*Ceratocampidae* HARRIS, Report insects inj. veg. Mass., p. 287. 1841.

*Ceratocampada* Packard, Proc. Ent. Soc. Phil. III, p 381. Nov., 1864.

*Ceratocampida* Kirby, Syn. Cat. Lep. Het. I, p. 739. 1892.

NEUNIGEN and DYAR. Journ. N. Y. Ent. Soc. II, p. 147. Dec., 1894.

*Citharopniida*: DIXON, Journ. N. Y. Ent. Soc. II, p. 174. Dec., 1894.

*Sphingicamunda* Packard, Psyche, p. 280. Dec. 1901.

**Family Characters.** Head small, but larger than in the Saturniidae, not prominent; in Adeloccephala, nearly concealed from above by the overhanging thorax. Front of the head either distinctly triangular in the most typical forms (Adeloccephala, Syssphinx, Eacles) or very narrow (Arsenura), or moderately wide, with a vestiture either closely cropped, or shaggy, or with the hairs long, uneven, and partly shading the eyes. When denuded, the front is formed by

the clypeus, the epieranium and occiput being very short and situated behind the insertion of the antennae. The surface of the clypeus or front is flat, as in all the saturnian moths, owing to the absence of a functional tongue; in *Syssphinx* the lower edge forms a knob-like protuberance. The eyes rather large, globose. Antennae of ♂ almost invariably bipectinated, either on the basal half or basal three thirds or three fourths, or to the end; with about 18 to 25 double pairs; the distal pectinations of each joint nearly as long as the basal ones, and both generally densely ciliated; they are sometimes plumose. In the ♀ either simple, subsimple, or with short, distinct pectinations, only a single pair to each joint. Labial palpi in general large and stout, sometimes (*Arsenura*) passing beyond the front; usually 3-jointed, sometimes 2-jointed (Eacles), or but 1-jointed and difficult to distinguish from the hairs of the front and sternum. They are large and *Sphinx*-like in Agliinae, especially in *Arsenura*, where the third joint, usually buried in the hairs of the end of the second joint, is distinctly seen. Maxillæ in many genera sufficiently developed to be visible, but even then small, weak, the two halves separate, very slender, and evidently not functioning, unless slightly so in Citheronia, where the two maxilla are united for about half their length to form the tongue. In *Anisota* there are no recognizable vestiges of a tongue.

Body robust, spindle-shaped, or fusiform, or in general *Sphinx*-like; the thorax thick, and the abdomen long, conical, and when the lateral claspers are large, as in Citheronia and *Syssphinx* and certain Adelocephalæ, the dense vestiture on them forms lateral terminal tufts; the abdomen is most conical in genera such as *Arsenura* and *Dysdaemonia*, the vestiture being closely cropped; in some genera the vestiture of the thorax is long, dense, and shaggy. There is rarely a prothoracic collar, one being slightly developed in *Arsenura* and *Dysdaemonia*. The patagia are rarely distinctly apparent, owing to the dense, long vestiture of the thorax.

The fore wings vary greatly in shape, in the more typical forms being in Ceratocampidæ sphingiform, the costa straight, the apex acute or subacute, the outer edge very oblique, or they may be very broad as in *Arsenura* and *Dysdaemonia*, or closely similar in shape to those of the saturnians (*Nudaurelia*, *Gynanisa*, etc.).

The hind wings equally vary from their normal proportions, the apex being rounded and the outer edge entire, or they may be *Sphinx*-like, or variously angulated or tailed, as in *Dysdaemonia*, in *Urota*, and *Cercophana*.

*Venation:* There are in the fore wings invariably eleven veins present, and in the hind wings eight or nine (nine invariably in the Ceratocampidæ, seven in Eudemonia), there being no vein VI. It also differs from that of the saturnians in the discal cell being invariably closed by the discal veins.

The discal cell is always closed, the cross vein, i.e., the two discal veins (anterior and posterior, or "discocellulars") united to form a continuous line, which is either bent, more or less, outward or inward, or regularly curved outward or inward, or directed obliquely outward and inward. The discal cell is often small, in the typical members of the family (Ceratocampidæ) very small, short and narrow, and not extending to the middle of the wing, but in some cases, in *Polythysana*, etc., it extends beyond the middle of the wing (along the cubital or vein IV), so that the veins beyond it may be very short.

Hind wings, with eight veins; the first or anterior discal vein is very oblique, directed inward and backward.

*Egg.*—Those of the Ceratocampidæ differ from those of the Saturniidæ in being low, somewhat flattened, broad, elliptical, not cylindrical; the shell is thin and tough, parchment like, while the sculpturing is partly obsolete. The eggs of the Agliinae and Bunaïnae are not well known.

*Larva.*—In the larva after stage I, as well as in subsequent stages, the setiferous tubercles are solid and chitinized, forming a stout, long spine or horn (never polysetose rounded knobs or button-like tubercles as in Saturniidæ), in some cases bearing a fine seta at the end. The suranal plate is armed with bosses, or in some cases with horns, with the result that the armature of the family in general is more formidable than in any other group of Lepidoptera. The anal legs or claspers are large, squarish, and solid. There is, with a few exceptions (*Anisota*), a caudal horn

on the eighth abdominal segment, due to the fusion in embryonic life of tubercles  $\gamma$ ; this horn being long, acute, not a knob or rounded tubercle as in Saturniidae.

*Pupa*.—The head-end of the body unusually full and rounded, overhanging the mouth region; the sutures between the abdominal segments deeper than usual; no primitive characters on the under side of the head, i. e., no traces of maxillary palpi and of second maxillæ, but the first maxilla either long or short; in the latter case the two maxilla together form a nearly equilateral triangle (Adelocephala and Anisota); cremaster usually very long and stout, forked, though sometimes (Citheronia) nearly atrophied; groups and lines of fine sharp spines on the head and thorax, or the body quite smooth and unarmed (Citheronia). The pupa is subterranean, the larva spinning no cocoon.

*Geographical distribution*.—The species are mostly antarctogeic, i. e., confined to South and Central America, from which a few species have migrated into America north of Mexico, and to the African continent south of the Sahara (*Afroptera*). The only European form is *Aglia tau*, while Salassa of the oriental region belongs to this family.

*Comparison with the Saturniidae*.—The Ceratocampidae as here considered is a much larger group than that to which Harris gave this name. As a large proportion, the Ceratocampinæ excepted, have hitherto been associated with the Saturniidae, we may here recapitulate our reasons for removing such a large body of genera from that group, and for establishing a new family or group for them. Our attention was first led to this conclusion by the great and apparent differences from true Saturniidae in the shape and structure of what larvae of the African genera were known, and their transformations.

But we will first call attention to the imaginal characters. In the first place the Ceratocampinæ are sufficiently distinct. In the Buncinae we have the greatest approximation to the Saturniidae. Our chief guide and reliance here has been the venation of the two groups. This is seen in the number and position of the veins, and the form, size, and completeness of the discal cell. The normal number of veins in the fore wings of Ceratocampinæ is eleven, though the second branch of the radial vein (vein III<sub>2</sub>) is sometimes absent, and very rarely the vein is undivided, only vein III<sub>2</sub> being present. In the hind wings the usual normal number of veins is eight.

On the other hand, the normal number of veins of the fore wings in the Saturniidae is eleven, but in Rothschildia, Samia, Telea, Antherea, Rhodia, and a few other genera there are but ten, while in Graellsia, Perisomena and *Caligula japonica* and *simila* there are but nine. This difference, however, is not significant, as it is due to the presence or absence of III<sub>1</sub> or III<sub>2</sub>, or both, these being short, unimportant veins. The usual, indeed so far as we know invariable, number of veins in the hind wings is eight. It thus appears that the normal number of veins is the same in the two families, the group Ceratocampinæ, which have nine veins in the hind wing, excepted.

#### Subfamily 1. CERATOCAMPINÆ Grote.

- Ceratocampida* HARRIS, Report Insects inj. Veg. Mass., p. 287. 1841.
- Ceratocampida* PACKARD, Proc. Ent. Soc. Phil., iii, p. 381. November, 1864.
- Ceratocampina* GROTE, List Lep. N. Amer., p. xiii. September, 1868.
- Ceratocampina* GROTE, New Check List N. Amer. Moths, p. 20. May, 1882.
- Ceratocampina* SMITH, Entomologica Amer., ii, p. 20. April, 1886. p. 44. May, 1886.
- Ceratocampida* KIRBY, Syn. Cat. Lep. Het., i, p. 739, 1892.
- Ceratocampina* PACKARD, Journ. N. Y. Ent. Soc., i, p. 7. March, 1893.
- Ceratocampida* NEUMORGEN and DYAR, Journ. N. Y. Ent. Soc., ii, p. 147. December, 1894.
- Citheroniida* DYAR, Journ. N. Y. Ent. Soc., ii, p. 174. December, 1894.
- Ceratocampida* DYAR, List N. Amer. Lepidoptera, p. 75. 1902.

*Subfamily characters*.—Head triangular, wide at the insertion of the antennæ and narrowing toward the oral region more rapidly than usual, coming to a point (especially so in Adelocephala, Syssphinx, and Eacles; considerably wider toward the oral region in Anisota and Citheronia). When denuded the front is seen to be more regularly triangular than in any other group of the family, or in the Hemileucidae or Saturniidae.

Antennæ of ♂ bipectinate on the basal two-thirds or three-fourths, beyond filiform, the distal

pectinations fine, slender, flat, and closely pressed to the basal branches of the next joint. (This type of antenna is very persistent, with no exception; those of ♀, either with a single pair of stout short pectinations (*Adelocephala bicolor*), or simple, without vestigial branches (Anisota, Adelocephala, Syssphinx, Eacles, and Citheronia, except in *C. principalis*, in which they are minute, tooth-like).

Palpi usually much reduced; in Adelocephala scarcely visible, short, feeble, depressed; where largest and best developed, not reaching the front (Eacles and Citheronia); denuded, 3-jointed (Anisota, Pl. XXXVI, figs. 10, 10a); in Eacles, 2-jointed (fig. 11).

Maxillæ varying in degree of development even in the same genus; not united to form a sucking tube; in Anisota, apparently no vestige left; in *Adelocephala subangulata*, they are comparatively well developed, and are as long as the filiform tip of the antenna; in Eacles, longer than in any other genus, but not visible without removing the scales; in Citheronia, as long as the front of the head in the middle (Pl. XXXVI, fig. 5).

Body Sphinx-like, or spindle-shaped, thick; thorax stout; abdomen large and rather long.

Fore wings usually narrow, Sphinx-like in shape in Syssphinx and many species of Adelocephala. The costa straight, apex acute, the outer edge very oblique; either simple or scalloped (as in Smerinthus), the inner angle nearly effaced; or the wings become wider, the costa more arched toward the apex, which tends to become square and the outer edge less oblique in Eacles and Citheronia, those of Anisota being intermediate in shape.

Hind wings also sphingoid in size and shape; short, very broad, and not reaching so near the end of the abdomen as usual; in Adelocephala and Syssphinx the costa very full, convex; apex rounded, outer edge somewhat excavated in ♂ or, as in ♂ Anisota, of a singular triangular shape, somewhat produced toward the inner angle; this characteristic especially emphasized in *A. virginiana*. The hind wings are most normal or conventional in shape in Eacles and Citheronia, where the outer edge of the wing is full and rounded.

Venation: Fore wings, eleven veins present; the discal cell smaller than in any other subfamily of the protosphingoid group; it is only about one-third as long as the wing, and very narrow, especially in Adelocephala, Syssphinx, Anisota, and Citheronia.

Vein IV<sub>2</sub> (or sixth radial) forming a true independent vein, being widely detached from its stalk, and situated in the middle of the extradiscal cell, i. e., just midway between veins IV<sub>1</sub> and IV<sub>3</sub>. This liberation or detachment of vein IV<sub>2</sub> is most marked in Eacles, but less so in Citheronia, yet the character is very persistent and fairly diagnostic, as much as any character can be.

The two discal veins taken together form an oblique line, which is directed outward in Eacles, the posterior discal vein being directed inward in Citheronia, while the line is straight in Syssphinx; in *Adelocephala bisecta* and *subangulata* the line is regularly curved. The course of these veins is peculiar and characteristic of the group in Adelocephala, Syssphinx, Anisota, and Citheronia.

Hind wing: Vein II (subcostal + radial vein) is almost sinuous in Syssphinx. There are invariably nine veins instead of eight (not counting I) (a diagnostic feature), this being the addition of vein VII; VIII being the second axillary vein. The discal cell very small; especially narrow in *Adelocephala bisecta*. The discal veins taken together form an oblique line, which is curved outward, especially in Eacles.

Vein IV<sub>2</sub> only partially detached, never forming a true independent vein, thus differing from the Aglinæ (though Aglia itself approaches Eacles in the venation of the hind wings).

Legs long, stout, strong, spined, the vestiture short and close, much as in Sphingidae. The fore-tibial epiphysis well developed, varying in shape from lanceolate to oval. (Pl. XXXVI, figs. 12-22.)

*Larva*.—Body sphingiform, and legs like those of the Sphingidae; head subconical, narrowing toward the vertex; the surface smooth, not finely spinulated with secondary spinules as in Smerinthinae. The trunk segments armed with long, sharp, dorsal and subdorsal curved spines, those of the prothoracic segment sometimes well developed (in the more primitive species of Adelocephala and Citheronia), but usually partially atrophied. A long, sharp caudal horn; between this and the thoracic horns the dorsal spines of abdominal segments 1 to 7 in the more

primitive species of Adelocephala high and of equal size. In Anisota but a single pair of dorsal mesothoracic horns, and the caudal horn is represented by two small separate tubercles.

In color and armature protected by their resemblance to the color of the foliage and spines of the spiny plants on which the more primitive species feed.

In stage I the body bears no glandular hairs, and the thoracic horns and caudal horn in all except Anisota are enormously long and end in a more or less bulbous knob, which gives rise to two rod-like setae.

*Pupa.*—The head is unusually full and rounded, overhanging the mouth-region and, the pupa being subterranean, is not provided with any large protuberances; the mouth parts present no vestigial characters; the maxillæ vary in length, the two together in Adelocephala and Anisota, whose imagines have nearly aborted tongues being scarcely longer than broad; abdominal sutures deeply impressed. The armature consists of small sharp spines, either on the head between the antennæ or on the prothorax, and elsewhere on the thorax. Metathoracic segment with a basal transverse irregular ridge on each side; the cremaster is very long, flattened, and deeply forked, or in Citheronia it may be nearly atrophied and functionless; the abdominal segments usually with two rows of fine sharp spines, but in Citheronia the segments are smooth. The surface of the body differs in degree of rugosity, either being deeply punctured or (Citheronia) nearly smooth.

The pupæ, then, of this group are recognized by the full rounded head-region and the unusually long, forked, flat cremaster.

*History of the group.*—As observed by Walsh, the group Ceratocampinae, as here understood, was first established as a distinct and exclusive American family by Doctor Harris, "but has been somewhat unnaturally united with Saturniidae by succeeding authors," referring to Harris, himself (Inj. Ins., p. 398), and to Morris. He adds that "Doctor Clemens has beautifully shown that it differs from Saturniidae, not only in the characters laid down by Doctor Harris, but also in having the subcosto-inferior nervule of the front wing *simple* and not *furcate*. (Proc. Ent. Soc. Phil., i. p. 177.) In other words, in Ceratocampidae the subcostal vein sends off toward its tip three branches or sectors which are all simple; in Saturniidae, the middle one of these three sectors, instead of rising directly from the subcostal vein, rises from the basal sector or branch, thus making that basal sector appear furcate." (Proc. Boston Soc. Nat. Hist., ix, Feb., 1864, p. 230, footnote.)

By Grote (List Lep., 1868) the name Ceratocampinae was proposed for the Ceratocampidae of Harris and the present author, Grote then regarding it as a subfamily of Bombycidae.

The name Ceratocampinae was also given to the group by J. B. Smith in 1886, it being by him regarded as a subfamily of Saturniidae.

It received the family name Citheroniidae from Dyar in 1896, who proposed that name on account of the generic name Ceratocampa being a synonym; in 1902 the same author restored the more fitting name Ceratocampidae. In 1901 (*Psyche*, ix, p. 280), however, we showed that it is a subdivision of the now more comprehensive family group for which we would use the name Ceratocampidae.

As it now stands the family Ceratocampidae of the older authors, Harris and others, has been found to be a subdivision of a much more extensive group of family, and possibly superfamily rank. The family Ceratocampidae as I have enlarged it, and as described in the foregoing pages, differs in egg, larval, pupal, and adult characters from either the Hemileucidae or the Saturniidae. None of the members are spinners, but when about to transform the larva enters the earth, the pupa being subterranean, its cremaster being a large stout spine.

To this extensive family group belong the great moths of central and southern Africa (Afrogea), which have hitherto been regarded as true Saturniidae. For example, Nudaurelia, of which there are about twenty species, and which, until separated by Rothschild, were confounded with the Asiatic genus Antherea, is in its larval, pupal, and imaginal characters closely allied to our American Ceratocampinae. This is also the case with *Gynautisa sis*, etc.

As the result of prolonged study of the venation, and what little we know of the larval and pupal characters, it is necessary to remove many, indeed most, of the African genera heretofore

associated with the Saturniidae, also the Eurasian genus Aglia and the Indian genus Salassa from the Saturniidae and associate them with the Ceratocampinae.

The group, as we are now disposed to limit it, is divided into several subdivisions of nearly equal rank.

We conclude, then, that the protosphingine group for which we have retained the name Ceratocampidae is represented by the following subfamilies, though we would add that they may ultimately be regarded as of family rank:

1. *Ceratocampinae* (Adelocephala, Syssphinx, Anisota, Eacles, Citheronia).

2. *Agliinae* (Arsenura, Rhescyntis, Dysdaemonia, Copiopteryx, Aglia, Cercophana, etc.).

3. *Bunaeinae* (Bunea, Lobobunaea, Imbrasia, Gynanisa, Cirina, Usta, Nudaurelia, Antherina, Melanocera, Cinabra, Aurivillius, etc.). The genera Cyrtogone, Eudæmonia, and others appear to be types of additional subfamilies.

#### SYNOPSIS OF THE GENERA.

##### *Imago.*

♂ Antennae with joints 1-17 or 18 doubly pectinated; ♀ antennae simply pectinated or simple; thorax full and overhanging the head; maxillæ slightly developed; body and wings sphinx-like.....	Adelocephala
Head (denuded), narrower than in Adelocephala; elyptus produced into a knob-like protuberance; body and wings sphinx-like .....	Syssphinx
♂ Antennae with joints 1-15 doubly pectinated; in ♀ simple; palpi short and feeble; maxillæ either wholly or nearly aborted; hind wings of ♂ triangular; costal edge much curved .....	Anisota
♂ Antennae broadly pectinated; fore wings wide, apex subacute; outer edge less oblique than in Citheronia; hind wings rounded; palpi 2-jointed .....	Eacles
Fore wings subacute at tip; hind wings rounded, but apex more produced than in Eacles.....	Citheronia

##### *Larva.*

Prothoracic segment with either spines or rounded tubercles; second and third thoracic dorsal and subdorsal spines but little longer than those of abdominal segments 1 to 7; caudal horn long, recurved .....	Adelocephala
Like those of Adelocephala, but the thoracic spines and caudal horn short and conical; none on abdominal segments 1 to 7 .....	Syssphinx
No fused caudal horn; two separate tubercles <i>i</i> present on eighth abdominal segment; a median spine on segment 9; body striped longitudinally .....	Anisota
Spines short and stout; no long prothoracic spines .....	Eacles
Spines all very long; long prothoracic horns .....	Citheronia

##### *Pupa.*

A. Maxillæ very short, the two together scarcely longer than broad.	
Cremaster very long, deeply forked; surface rugose .....	Adelocephala
Cremaster very long, deeply forked; surface smoother .....	Anisota
B. Maxillæ long.	
A long stout cremaster .....	Eacles
Cremaster vestigial, reduced to a small bilobed tubercle, shorter than broad .....	Citheronia

*Habits.*—Pupa subterranean; the larva spinning no cocoon.

*Geographical distribution.*—Confined to Neogaea, from which a few species have migrated into eastern America north of Mexico, and east of longitude 100. (See fig. 6 and maps I-IX.)

#### ADELOCEPHALA Herrich-Schaeffer.

##### Plate XIX, etc.

*Dryocampa* HARRIS, Rep. ins. Mass., p. 293. 1841.

*Sphingicampa* WALSH, Proc. Bost. Soc. Nat. Hist. IX, p. 290. 1864.

*Adelocephala* HERR.-SCHAEFFER, Aussereurop. Schmett. I, pp. 60, 78. 1855. (No deser.)

*Othorene* BOISDUVAL, Annales Soc. Ent. Belgique, XV, p. 82. 1872.

*Adelocephala* BOISDUVAL, Annales Soc. Ent. Belgique, XV, p. 85. 1872.

JEWETT, Papilio, II, p. 38. March, 1882.

KIRBY, Syn. Cat. Lep. Het., I, p. 741. 1892.

DRUCE, Biologia Centr. Amer. Lep. Het., I, p. 170. 1885.

*Sphingicampa* KIRBY, Syn. Cat. Lep. Het., I, p. 740. 1892.

NEUMOGEN and DYER, Journ. N. Y. Ent. Soc., II, p. 148. Dec., 1894.

*Adelocephala* and *Syssphinx* (in part) DYER, Proc. Ent. Soc. Wash., IV, p. 427. May 13, 1901.

*Imago*.—♂ and ♀ head as in *Anisota*, but tending in front to be more triangular, and narrower toward the labrum; it is widest in *A. bicolor*, narrowest in *A. bisecta* and especially in *A. montezuma* (Pl. XIX, fig. 6). Antennae of ♂ bipectinate, with 17 to 18 pairs of pectinations which are exactly as in *Anisota*; the 12 joints of the filiform extremity very short; in ♀ simple, except in *A. bicolor*, which has 16 pairs of short, thick, subelavate pectinations, a single pair to each joint. Palpi short, varying in length, just visible, not reaching the front. Maxillae varying in length, not visible in *A. bicolor* and *A. heilighrodtii*, but in *A. subangulata*, the more primitive form, they are comparatively well developed, though separate from each other; they are curled up, and are nearly as long as the filiform tip of the ♂ antenna; they are also present in *A. wardii*, but very slender and short. Fore wings either of the usual generalized form, with the costa convex toward the apex, the latter obtuse, and the outer edge full (*A. bicolor*, *A. quadrilineata*,



Fig. 6.—Distribution of the subfamily Ceratocampinae.

*A. heilighrodtii* and *A. albolineata*), and the hind wings rounded; or they are triangular, with the outer edge oblique, not full, and the hind wings subtriangular, and not reaching beyond the basal two-thirds of the abdomen. The abdomen of the ♂ is acute at the end and with a tuft on each side of the tip in *A. subangulata*.

Venation: Much as in *Anisota*, there being no vein  $III_2$ ; vein  $III_1$  arises midway between the anterior discal vein and base of common stalk of veins  $III_1$  and  $III_2$ ; the greatest departure is in *A. subangulata* (Pl. XXXVIII, figs. 1, 1a) where  $III_1$  arises at the same point as the anterior discal vein, in front of the origin of vein  $IV_2$ ; venation of hind wings nearly identical with that of *Anisota*.

Coloration: Ocherous, with the hind wings more or less pink; the markings differ very much in the different species; in *A. bicolor* there are two twin discal dots, in *A. heilighrodtii* the fore wings are stone gray; in *A. albolineata* the lemon-ocherous wings are crossed by conspicuous white lines, and in *A. bisecta* there are no discal spots, while in *A. subangulata* and *A. montezuma* there is a large discal spot on the underside of the fore wings.

The genus, as shown by the larval characters, is more generalized than *Anisota*, since the spines on the prothoracic and abdominal segments are larger, and the sphingiform imagoes or moths are rather more primitive and ancestral.

The species of the genus differ very considerably, and may be divided into several groups or what may be perhaps regarded as incipient genera. The most sphingiform group of species and that nearest *Syssphinx* is the Brazilian *A. subangulata*, *A. fullae* Boisd., and *A. bisecta*, while the rounder-winged species *A. albolineata*, *A. hellmayrii*, and *A. bicolor* are later, more degenerate, or modified forms. *A. bicolor*, with pectinated ♀ antennae, shows a remarkable divergence from the normal ♀ form, the front of the head being wider, while the tongue is not visible. We consider those species with a well-developed tongue as the more primitive forms.

Druce states: "Adelocephala I think will have to be divided, the typical species having pectinated antennae in both sexes, those of the *A. albolineata* group being only pectinated in the males. I have not sufficient material, however, to be certain how far this character holds good." It appears, however, that only *A. bicolor* has pectinated antennae in the female. (See fig. 8.)

The South American and our *A. bisecta* are apparently the more primitive forms, both as regards the sphingoid shape of the body and wings and the more fully developed maxilla. As the type found its way into North America it seems to have undergone a reduction of the maxilla until they practically became aborted, while the outlines of the wings became less distinctive and less specialized, as seen especially in *A. bicolor*, which in this respect approaches *Anisota*. It is interesting to observe that all the South American species (except *A. anthomitis*) have sharp fore wings and subtriangular hind wings, while in several of the Central American and North American species the wings tend to become broad and rounded at the apex.

The most aberrant species is *A. albolineata*. Its maxillæ are comparatively well developed. I have not been able to examine the male antennæ, having no examples of that sex. It differs in venation from all the other species in the much wider discal cell of both wings, and in vein III<sub>1</sub> of the fore wings, which arising between the anterior discal vein and III<sub>2</sub>, springs off very near the origin of the latter. The two discal veins taken together form a straight line, not being curved as in most of the other species; the subcosto-radial (II) vein is much curved, so that the cell between this and III is much wider than in any other species of the genus. If the genus is to be subdivided *A. albolineata* should be generically separated from all the other species, but it is better to wait until we know the larva and its history.

*Egg.*—Flattened, oval-cylindrical, disk-like, each end alike. Shell smooth under a low power, but when highly magnified seen to be ornamented with faint polygonal areas, with a swollen nucleus in the center.

*Larva.*—Head subconical, narrowing above. Body cylindrical, inclined to be slightly compressed; in the more primitive species all the segments, except the prothoracic, bearing long, high, saber-shaped dorsal spines as long as the body is thick; tubercles  $\text{\textgreek{z}}$  nearly atrophied; in the more specialized species (*A. bicolor*, etc.) the four thoracic and caudal horns much longer than the abdominal ones; of the latter those on each, or on the second, fourth, and sixth segments, are stout, conical, smooth spines, conspicuously tinged with silver and rose red; no median spine on the ninth abdominal segment; suranal plate coarsely tuberculated, but with no specialized spines.

*Young larva, stage I.*—Armed with four thoracic horns, three-fourths as long as the body, and ending in bulbs bearing two dark rods; caudal horn spinulated, large, as long as the body is thick, divided deeply into two setiferous lobes; tubercles  $\text{\textgreek{z}}$  present on abdominal segments 1 to 9; suranal plate with three lateral and two terminal setiferous tubercles; the body marked with conspicuous longitudinal stripes.

*Pupa.*—Body moderately stout, head rounded; maxille short, taken together forming a nearly equilateral triangle; a group of three stout spines at base of and between the antennæ, as in *Anisota*; surface of the integument more rugose than in *Anisota*, and the spines a little stouter; the cremaster is long, slender, narrow, rather deeply divided at the end, but not differing from that of *Anisota*.

The short maxilla of *A. bicolor*, the only species whose pupa has been examined, show that these appendages have been aborted in some ancestral form.

*Geographical distribution.*—A South and Central American genus; the more primitive generalized forms being neogaicæ—i. e., Brazilian, and extending into the Argentine Republic. The North American species extend from Mexico into the Southwestern States and northward along the Mississippi Valley and Atlantic coast—i. e., inhabiting the Austro-riparian and southern and middle portions of the Appalachian subprovinces.

*Synonymical history.*—Although Herrich-Schaeffer's name *Adelocephala* has the priority, Walsh's name *Sphingicampa* is much more descriptive and applicable. He not only described the imago, but gave a detailed description of the larva and pupa. *Adelocephala* was apparently



FIG. 7.—Distribution of the genus *Adelocephala*.

first proposed in 1888, by Boisduval, but the first printed and published mention of it is to be found in Herrich-Schaeffer's *Aussereuropäischer Schmetterlinge*, as mentioned above in the synonymy. Boisduval's *Othorene* can not be separated from his *Adelocephala*, while, in the future, when its transformations are known, *A. albolineata* may be found sufficiently distinct to be assigned to a separate genus.

Until we know the details of the life history of each species of this genus it would not be advisable to split it up into distinct genera. After carefully working out, with what material I have had, the larval forms and histories, and the head and antennal characters, as well as the

venation and genital armature of the moths, I do not find it possible to divide up the genus, although it would be most desirable if so apt a name as Walsh's *Sphingicampa* could be retained. The most aberrant species as regards its venation is *A. albolineata*, and when we know the larva, and have studied the male genitalia, this species may have to be referred to a separate genus.

I scarcely think that from the facts here given Doctor Dyar is warranted in referring all the species of *Adelocephala* which have simple antennae in the female to *Syssphinx*. That name should obviously be retained for *S. molina* alone unless *S. petersii* should prove to be a member of that genus.

The larva of *Syssphinx molina* differs from any of those of *Adelocephala* in the general reduction of the spines. In venation it approaches nearest to *A. bicolor* in vein III, and in the size and shape of the discal cell of the fore and hind wings; the antennae do not seem to afford in this subfamily reliable characters. As regards venation, *A. albolineata* is the most aberrant, while *A. bicolor*, *A. heliographica*, and *A. subangulata* form a group by themselves; and *A. bisecta*, with *A. montezumae*, are closely allied.

If we consider the ♂ genital armature, *Adelocephala* may be divided into three groups: 1, with the claspers rounded, *A. bisecta* and *heliographica*; 2, claspers acute, with the suranal plate and penis very different from 1, *S. bicolor*; 3, *A. subangulata*, in which the armature differs from all the other species examined.

In his diagnosis of *Othorene*, Boisduval states that the female antennae are pectinated. He places under this genus the following species: *A. cadmus*, *jason*, *fallax*, *mexicana*, and *wardii*. Doctor Dyar considers the pectination of the female antennae as a generic character, and places *A. bicolor* and *cadmus* in *Adelocephala*, referring *A. bisecta*, *A. heliographica*, and five Brazilian species to *Syssphinx*. However interesting this difference in the female antennae may be, the two groups regarded as genera by Dyar appear to contain quite incongruous material, and do not appear to us to be natural genera, as genera go.

Until the larval forms of all the species of *Adelocephala* are known it would scarcely be possible to present a natural classification, or to make an attempt at a phylogeny of the numerous species of this genus.

It seems evident that *A. anthonilis*, whose larva has well-developed prothoracic dorsal spines, is one of the most primitive species. Then would come our Brazilian larva (Pl. III, fig. 1), and that of *Adelocephala breris*, figured by Peters (Pl. III, fig. 5); also *A. leucantha*, of which Boisduval says: "La collerette est garnie d'une rangée de petites pointes assez saillantes;" also, that the dorsal abdominal spines are of equal length, while the dorsal and caudal horns "sont un peu dentelées."

Then would follow the larvae with long, even, dorsal spines, except those on the prothoracic segment, which are reduced to button-like tubercles, as *A. subangulata* (Peters, Pl. III., fig. 4). These would be succeeded by the more specialized species, in which the abdominal dorsal spines are short and long on alternate segments, including *A. wardii* and our United States species.

We are therefore under the circumstances compelled to begin with the most recent and best-known species, *A. bicolor*, and the others occurring in the United States, and then consider those of Central, and lastly those of South America, though the genus originated in Neogaea.

#### ADELOCEPHALA BICOLOR (Harris).

Plate XIX, fig. 3;

*Dryocampa bicolor* HARRIS, Rep. Ins. Mass., p. 293. 1841; Treatise ins. inj. veg., p. 408. 1862.

MORRIS, Synopsis Lep. N. Amer., p. 232. 1862.

*Sphingicampa distigma* WALSH, Proc. Bost. Soc. Nat. Hist., IX, p. 290. Feb., 1864.

*Sphingicampa bicolor* (?) WALSH, Proc. Bost. Soc. Nat. Hist., IX, p. 293. Feb., 1864.

*Anisota bicolor* GROTE, Proc. Ent. Soc. Phil., III, p. 93. June, 1864.

*Dryocampa bicolor* PACKARD, Proc. Ent. Soc. Phil., III, p. 384. Nov., 1864.

*Adelocephala bicolor* var. *innocula* JEWETT, Papilio, II, p. 144. 1882.

*Adelopheda bicolor* var. *suprema* NEUMOGEN, Ent. Amer., I, p. 94. 1885.

*Sphingicampa bicolor* KIRBY, Syst. Cat. Lep. Het., I, p. 740. 1892.

*Sphingicampa bicolor* NEUMOGEN and DYAR, Journ. N. Y. Ent. Soc., II, p. 148. Dec., 1894.

*Adelocephala bicolor* DYAR, Proc. Ent. Soc. Wash., IV, p. 428. May 13, 1901.

*Larva.*

## Plates XLV and XLVI.

Walsh, B. D., Proc. Bost. Soc. Nat. Hist., IX, p. 292. Feb., 1864. Last stage, also *pupa*.

Jewett, H. S., Papilio, II, p. 38. March, 1882. All stages. Also *egg*.

Pickard, A. S., Proc. Amer. Phil. Soc., Mar. 17, 1893, p. 147. Egg and larval stages, fig. 2, spines.

*Imago*.— $2\delta$ ,  $2\varphi$ . Head visible from above; front moderately wide; palpi very short, maxillae not visible. Antennae of  $\delta$  with short joints; bipectinate on the basal three-fourths, tip filiform, but the single pectinations are distinct, quite well developed, though not ending in a seta; in  $\varphi$  antenna unipectinate, i. e., the pectinations of basal pairs thick, subclavate, and well developed to a little beyond the middle, the longest pectinations being nearly twice as long as the joint bearing them; the filiform tip with minute teeth. Head, thorax, and fore wings ocherous or isabella, often pinkish ocherous.

Fore wings with the costa more convex on the outer half than usual; apex obtuse, outer edge full and convex, inner angle much rounded. The two sexes are much alike, so that it is difficult to distinguish them by the shape of the wings or their coloration. Fore wings ocherous or isabella brown, with thick-set, dusky strige. Basal line obsolete, extradiscal line faint, diffuse, dusky, sinuous, ending on the costa rather far from the apex; it is interrupted by the veins. In

one  $\delta$  the wing beyond this line is pinkish. Two distinct conspicuous white discal dots, varying in size, those on the same wing not equal in size; sometimes one or all are nearly obsolete or wanting.

Hind wings not quite reaching to end of the abdomen in either sex; pale or dark roseate; paler, almost ocherous on the outer margin and on the costa; in one  $\delta$  the pink is of a rich and dark color, deepening in hue toward the base of the wing.

Underside of fore wings deep roseate, paler beyond the diffuse extradiscal line and on the costal edge ocherous. Hind wings pale pinkish ocherous, clear, with large, dusky strige. No discal spots on the wings of either pair. Abdomen of the  $\delta$  somewhat flattened, tufted at the end; in both sexes pinkish above and beneath. Legs dark; fore legs of  $\delta$  with a broad, flat leaf-like tibial sack, sharp at the end and about half as long as the tibia itself. (For the venation see Pl. LVII, figs. 1, 1a, 1b.)

Expanse of fore wings— $\delta$  60–75 mm.;  $\varphi$  78 mm. Length of a fore wing— $\delta$  26–35 mm.;  $\varphi$  34 mm. Breadth of a fore wing— $\delta$  13–15 mm.;  $\varphi$  18 mm.; length of hind wing— $\delta$  18–24 mm.;  $\varphi$  22 mm. Breadth of hind wing— $\delta$  14–15 mm.;  $\varphi$  15 mm.

It varies in the ocherous hue of the fore wings, in the pink hue of the hind wings, and in the presence or absence of the discal dots, though they are usually present, and in the presence or absence of the extradiscal line.

The  $\varphi$  antennae are pectinated and the other secondary sexual characters are slightly developed. The body of the male is feminine in appearance, the abdomen being full and thick; the hind wing in both sexes is of nearly the same size and the coloration is the same.

*Geographical distribution*.—New Jersey (a single specimen taken on the coast, Smith); Iowa (var. *suprema*), Cedar Rapids, Iowa (G. H. Berry); Columbus, Ohio (W. N. Tallant); Dayton, Ohio (Jewett); Kentucky; North Carolina (Harris); Arkansas (Grote). Not reported from Mexico. (See Map I.)

This species is evidently distributed throughout the southern Appalachian subprovince, and with little doubt ranges over the entire Austroriparian subprovince, and may be found to extend into Texas and Mexico.

Edwards's var. *immaculata*  $\delta$  and  $\varphi$  only differ, as I find on examining his types in the American Museum of Natural History, in the speckles being obsolete, though in the  $\delta$  there are traces of them to be seen. They are from Dayton, Ohio.



Dr. H. S. Jewett has already (*Papilio*, II, pp. 38 and 144) fully described the egg and the larval and pupal stages of this interesting insect, and I have only to add some details omitted by him. My descriptions were drawn up from living specimens, supplemented by examination of the alcoholic specimens of the different stages. We have, perhaps, a no more interesting and beautiful caterpillar, whether we consider its peculiar appendages, its rich and gorgeous coloration, or its defensive habits, and the most carefully described details will not be superfluous in comparing the different stages with those of its allies, *Citheronia regalis* and *Eacles imperialis*, and the allied South American forms. I am indebted to my friend, Mr. W. N. Tallant, of Columbus, Ohio, for sending me a good supply of eggs from which the second or July brood of larva hatched. The food plant is the honey locust (*Gleditschia triacanthos*), though Doctor Jewett adds *Gymnorladus cyanoides*, or Kentucky coffee-tree.

*Egg*.—Flattened oval, disk-like, each end alike. Length, 1.8 mm.; width, 1.5 mm. At first green in color, as the embryo grows, states Jewett, the egg becomes biconcave and changes to yellowish brown, and from thirty-six to forty-eight hours before hatching the head of the larva shows through as a dark brown spot. The egg is about one-half as large as that of *Eacles imperialis*, but of the same shape. The shell under a lens appears smooth, like parchment; under a one-half inch objective the surface is seen to be ornamented with very faint polygonal impressed areas, which are much fainter and less easy to detect than those of the egg of *E. imperialis*. The swollen nucleus or bubble in each polygon is very indistinct.

It is interesting to compare the sculpturing of the shell with that of *E. imperialis* and *Citheronia regalis*, the former being intermediate between *Adelocephala* and *Citheronia*. In *E. imperialis* the shell is sculptured a little more distinctly with irregular polygonal imprints which are not so closely crowded as in *Citheronia*, and the median raised nucleus or bubble is pale but tolerably distinct. Length, 3 mm.; width, 2.5 mm. In the shell of the egg of *C. regalis* the polygonal impressed cells are easily recognized under the microscope and faintly detected under a strong lens. The cell imprints are much more distinct and more crowded than in the two other genera, while the median nucleus or bubble is more prominent and darker; it varies in diameter in different cells, being from about a third to a half as wide as the cell itself. The walls are quite irregular and not always distinct.

*Larva stage I*.—(Described four to five hours after hatching.) Length, 4 mm. The head is large, rounded, smooth, unarmed, except with a few scattered tapering dark hairs; it is blackish chestnut; it is wider than the body and slightly wider than the prothoracic segment, which is broad and flaring in front, as in *Anisota*; it is rather higher than wide, and on the vertex slightly bilobed, and is paler in front than behind. The terminal joint of the antenna is slightly bulbous and bears, besides the tactile bristle, about three olfactory rods.

The body is subcylindrical, a little flattened, but not so much so as in *Anisota*. The prothoracic segment is broad and flattened, smooth and unarmed, except with about a dozen dark small hairs. On each side of the second and third thoracic segments is a subdorsal pair of remarkable movable spines, nearly two-thirds as long as the body, which open and close together like great arms, spreading apart, or directed forward and outward more or less constantly while walking, the creature at this age being rather active; they are evidently at this period defensive or deterrent organs; they are stout, thick at the base, those of each pair close together at their base; they slowly taper toward the end, and are armed with 12-14 short, thick, blunt, dark spines. At the end of the spine is a remarkable bulbous expansion somewhat chestnut shaped, being a little flattened and subtriangular, broad at the end, from each side of which arises a small slender tubercle bearing a blunt, stout, dark, rod-like spine about a third longer than the tubercle. The appendages themselves are dark chestnut, pale amber at base and on the outer third, but the bulbous tip is dark reddish black. Those of the the third thoracic segment are very slightly shorter than the pair in front, and in each pair the outer, i. e., subdorsal spine is the shorter. These horn-like appendages are flexible, especially near the end, and are sometimes bent over and around, so as to form a decided bow or curve, or even a nearly complete circle. Compared

with those of *Citheronia regalis*, which they most nearly resemble, those of *Eacles imperialis* being forked at the end, the bulbous tips are a little longer, but still of the same general shape and size.

Along the abdominal segments are six rows of very long and slender conical tubercles ( $\gamma$ ), giving rise each to a single black seta, which is about a third longer than the tubercle. There are thus eight setiferous tubercles on each segment (1-7), the lowest of which, one on each side, is situated just above the base of the legs, and has a double base ( $v$ ), sending off posteriorly at nearly right angles to the main tubercle a small lateral one, which emits a black bristle. Tubercle  $\gamma\gamma$  is also present, being about as high as  $\gamma$  is thick at the base. On the eighth segment is a very large, stout, acute, bright-red horn, which is borne either erect or directed a little forward. It ends in two long, slender tubercles, each bearing a bristle about as long as the tubercle, and along the trunk are several long spinose tubercles, each ending in a black bristle. The dorsal median tubercle on the ninth segment is broader than long, being transverse, and bears two bristles. The suranal plate is rather narrow, much narrower than long, and ending in two long, slender tubercles, each bearing a dark bristle, besides four other bristles on the plate. The anal legs are provided with a dark patch on the side and bear below two long bristles, while there are three black bristles on the base of each middle abdominal leg. There are sixteen (possibly eighteen) crochets on each of the abdominal legs.

The body in general is pale green, with a slight yellowish tinge. There is a median linear dorsal line along the body, and on each side are four narrow dark lines on a green ground, the two middle lines being diffuse and inclosing a dark band and bearing a row of bristles.

The freshly-hatched larva spins a silk thread, which after a while is annoying to the observer from its being in the way and adhering to the leaves of its food plant.

*The larva, July 17.*—Just before molting. Length, 7-9 mm. (fig. 2). The head is now small, black, one-half as wide as the body, which is filled out from five days' feeding. The longest thoracic spines are scarcely one-third as long as the body, and all are pale reddish amber at base and on the outer third, the terminal knobs being black-brown. The caudal horn is also pale reddish amber at base. The dorsal tubercles of abdominal segments 1-7 bear a minute line at the base behind. There is now a definite, broad, white lateral stripe along the abdominal segments (not appearing on the thoracic), which is bordered above by a dark, thread-like, brownish, spiracular line, inclosing the spiracles, which are minute and difficult to detect. Above the spiracular line is a linear distinct white line, and above this is the pale-green subdorsal stripe, diffusely edged on each side with a darker tint. There is a median, small, rounded, amber-colored, dorsal tubercle on the ninth segment, which is double, bearing two bristles. The end of the suranal plate is reddish amber, bifurcate and bearing black bristles (fig. 2). There is a dark patch on the outside of the anal legs.

*Stage II.*—Molted July 18 and 19. Length, 10 mm. (fig. 3). The head is now high, slightly angular on the sides; black-brown with a light brown or greenish lateral stripe on each side, diverging from the light-green vertex to the antennae, the two stripes varying from pale brown to green. The great spines (both thoracic and caudal) are of about the same proportions and colors as in stage I, except that the eight thoracic spines, which are still no shorter in proportion to the body, being still one-third as long as the body, are not so much swollen at the end, the bulb being shorter and broader and the spines larger, making a more decided fork (fig. 3,  $a$ ), and thus resembling those of *Eacles imperialis*. The setiferous tubercles on each segment are now rather large, conical, the two dorsal ones ( $\gamma$ ) large and stout, twice as large as the subdorsal ( $\gamma\gamma$ ) and lateral ones, and all being lemon-yellow (less greenish than before), bearing a terminal black spine, and with a second minute piliferous tubercle growing out from the side.

The dorsal lines have almost disappeared, there being a subdorsal, pale, almost whitish line, besides a faint, narrow, dorsal, greenish line. The lateral ridge is now prominent and bright lemon yellowish, forming a distinct broken line, bearing in the middle of each segment a very slender, blackish, piliferous wart. A dark reddish purple, narrow, spiracular line. Between this and the yellow line is a white stripe and another narrower one above it, while still above is

another reddish purple line. Otherwise the markings are the same. The suranal plate, however, is edged with lemon-yellow, being the continuation of the lateral yellow band.

Thoracic and abdominal legs "green tipped with brown" (Jewett).

An examination of fig. 9 (in the text) will illustrate better than a prolix verbal description the appearance of the spines in stages I and II of this species. They are all drawn with the camera, and it is to be observed that the "horns" are more like those of *Citheronia regalis* than *Eacles imperialis*. *a*, one of the horns on the second thoracic segment; *a'*, the extremity enlarged, showing the circular corrugations; *a''*, the same more magnified; *a'''*, a terminal spine enlarged, showing its mode of insertion; it contains a central mass of minute globules; *b*, the first abdominal segment enlarged to show the position of the dorsal, subdorsal, suprspiracular and spiracular stripes, the latter inclosing the spiracle; also the position of the four spines, one dorsal (*i*), one subdorsal (*ii*), and two infraspiracular; the spines are all minutely barbed; *c*, a dorsal spine (*i*), bearing a spinule (*ii*) at its base; *d*, "caudal horn" or medio-dorsal spine on eighth abdominal segment; *ix*, that on the ninth segment; it is small, conical, and forked at the end, each fork bearing a long seta. All the foregoing in stage I. *f*, a "horn" from the second thoracic segment, stage II; the two terminal spines have entirely changed in shape, being larger and longer and bearing a tapering fine bristle; a third smaller conical tubercle has appeared near the base of one of the forks. The spinules on the trunk now bear a bristle; *e*, "caudal horn" of stage II; now large and high, deeply forked at the end; the spines or tubercles on the trunk of the horn now bear each a slender bristle.

*Stage III*.—Molted July 26, 27. Length, 13-15 mm. (Pl. XLVI, fig. 1). The head is now much larger, high, the face subtriangular, not black as before, with a green lateral stripe, but pea-green with a yellow stripe on each side, shaded more or less with black between the yellow V; and on the outside, in one example, the black is reduced to a diffuse patch inside, while in another larva it is outside of the yellow V. The head is now nearly as wide as the body.

The eight horns are still about one-third as long as the whole body and are now paler than before, being reddish chestnut and yellow at base, with black spinules and blackish at the tips, which are now not bulbous, but irregularly forked, the fork much shallower than in stage II; they are thicker than before, and the outer ones of the first pair are much shorter than the dorsal ones. The spines along the body are larger and stouter than before, with shorter setae: the tubercles at base are deeper yellow than before, tipped with black, while the high, conical, or (sometimes) rounded granulations are snow-white. The lateral yellow stripe along the body is more distinct than before: it is bordered above with pure white, and above this is the linear dark purple spiracular line, shaded above more distinctly than in the preceding stage with deep blue-green or verdigris-green; the caudal horn considerably higher than before, being one-fifth as long as the whole body: it is pink, with white spines bearing black bristles. The larva also differs from that of stage II in the suranal plate, which is more deeply forked, the forks being thicker, larger, and with several tubercles; the sides of the plate are heavily spined and on the surface are about six central, small, conical spines. Now, the dorsal abdominal spines are distinctly ivory-white on the outer side from the base up to the dark tip. The spiracles are much larger than before, distinctly interrupting the dark purple spiracular line, which is paler than before.

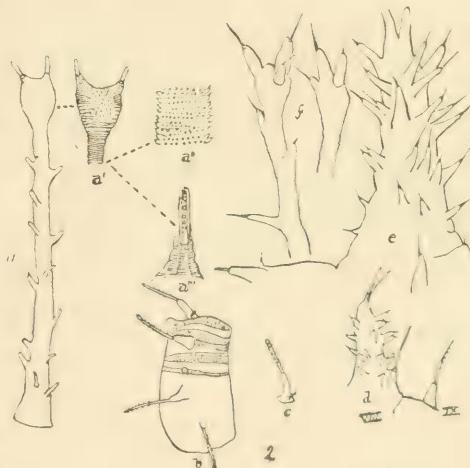


FIG. 9.—*A. bicolor*, armature of stages I and II.

*Stage IV.*—It is possible that the larva described by me in the Proceedings of the American Philosophical Society were small or freshly molted specimens, since an alcoholic specimen represented by fig. 2, 20 mm. in length, and in which the dorsal abdominal spines are small, not being differentiated as in the last stage, evidently is in the stage before the last. In this stage, also, the two dorsal spines on the first abdominal segment are simpler and a little smaller than those on the succeeding segment.

I therefore copy Doctor Jewett's description of this stage, which gives the markings and colors:

"Larvae passed their third molt June 13, three-fourths to seven-eighths of an inch long, nearly cylindrical, green. Head green, bilobed, minutely pubescent. Mandibles brown, covered with minute hairs. First segment at first as in last molt, but toward the end of this molt it becomes very prominent and subtriangular in shape, with a yellowish-white line on each side of anterior border, running from near the dorsal to the stigmatal line. The protuberances on the second and third segments have now lost the knobs at their extremities and are brown in some larvae and green in others. The only other changes are that the horn-shaped tubercles on the fifth to tenth segments are now larger and more prolonged, and are pink on the inside ~~and~~ have the appearance of burnished silver externally, and the stigmatal line is occupied by a marked band of color, consisting of a dark carmine line (passing through the inconspicuous green stigmata), bordered above by a narrow pale blue and below by a white line. The legs of some larvae are green and of others brown. Prolegs of some, green, and in others green tipped with brown. In some larvae the stigmatal space has numerous small black tubercles on each segment; in others there are no black tubercles."

*Stage V* (figs. 3, 3a).—Not seen to molt, but it probably occurred August 1 or 2. Length, 25–28 mm. The head is, as before, with two yellow stripes, one on each side, and bordered more or less on each side, especially in front, with black. The four pairs of thoracic horns are now but little longer than the body is thick and are reddish flesh-color, dark at the slender, slightly forked tips, and yellowish green at the base.<sup>a</sup> The "caudal horn" is now considerably shorter in proportion than before, being about two-thirds as long as the body is thick, and is of the same peculiar deep flesh-red as the thoracic horns. The sharp, stout, spine-like tubercles on the fourth and sixth abdominal segments are slightly over twice as large and thick as the other dorsal tubercles, which are as in the previous stage, and bear a verticil of from three to five short, blunt spinules; they are now silvery white on the outside (Jewett says burnished silver). The lateral yellow, carmine, white and blue bands are much as before. The increase in size of this stage over the preceding one is noticeable.

In his account of this stage Jewett states that the head is "green, bilobed, minutely pubescent," also that the thoracic horns had lost their knobs at their extremities; but this takes place at the time of the second molt.

In a larva 20 mm. long, and probably of stage IV, the lateral band is tricolored, marked with straw-yellow, the yellow inclosing the base of the black spines. Jewett says: "The legs of some larvae are green and of others brown. Prolegs of some green and in others green tipped with brown. In some larvae the stigmatal space has numerous small, black tubercles on each segment; in others there are no black tubercles."

The following description of another larva, drawn up October 10 and in the last stage, may be useful:

Pl. XLVI, fig. 3.—Length, 24 mm. Body rather thick. Head remarkably Sphinx or Smerinthus-like, as wide as the body, flattened in front, broad below about the mouth, but narrowing toward the vertex, as in Sphinx; the skin rough; with two lateral, rather broad, yellow lines, which arise from the base of the antennae and converging nearly meet on the vertex; across the upper division of the clypeus is a blackish band which adjoins a black blotch on each side, and which touches the yellow line. Labrum pale yellowish, blackish in the middle; eye-patch and mandibles black.

<sup>a</sup> Jewett says the spines are "brown in some larvae and green in others."

Prothoracic segments very slightly wider than the rest of the body in front: the front edge flaring and rising up somewhat collar-like; this edge armed with a single row of white tubercles, about 10 on each side of the segment, those above nearly adjoining at base and tinged with yellow; those on the sides below pure snow-white: behind the front edge are four small but distinct white warts, two in the middle.

The second and third thoracic segments each with two widely separated pairs of horns, not quite so thick as the caudal horn, each about two-thirds as long as the segments bearing them are wide; they are slightly recurved and scattered over them are conical, white tubercles which are irregular and blunt at the end; they are yellowish at base, near the middle becoming dark pink and at tip reddish black-brown. On the front edge of the second thoracic segment between the horns is a row of three conical sharp tubercles, with a similar and some minute ones on each side, while on the third segment are two similar white warts.

Across the dorsal side of the abdominal segments 1-7 are two rows of white, sharp, conical tubercles; two of those on the front edge of each segment being longer and sharper than the others and directed backwards. On these same segments (1-7) is a third set of curious tubercles, mostly large, conical and black internally, but on the outside shining opalescent pearl or silvery white, and resplendent, glittering brightly by lamplight. Of these curious spines those on the first abdominal segment are smallest, and those on segments 4-6 are largest, being about one-third as long as the caudal horn: the pair on segment 6 being the largest. The "caudal horn" on the eighth segment is large, with a few white tubercles, those at the end of the horn being reddish; the tip is slightly forked, there being two minute tubercles; all those on the sides of the horn bear a short, fine hair. In the middle of the ninth abdominal segment and in a position homologous with the caudal horn, is a minute, short, median, white wart, which is reddish at the base. The suranal plate and hind legs are very large, the surface rough and heavily warted, especially on the edges; the lower edge of the anal legs and suranal plate are interrupted with black. The eighth and ninth segments and base of the suranal plate are a little wider than the middle abdominal segments. The suranal plate is a little longer than wide, subacutely triangular, the tip forked and ending in two rather large tubercles, which are greenish at the end, blackish at base, with a little transverse median black stripe in front.

The stigmata are deep flesh-colored, with a slit in the middle, whitish, especially at the end. The stigmatal line along the side of abdominal segments 1-8 is whitish, edged above with purple, and still above washed irregularly with livid, greenish blue, while from the eighth segment to the tip of the suranal plate the line is straw-yellow. Below, near the base of the feet, is a lateral row of sharp, black spines; there are several on the sides of the thoracic segments, and one rather large one under each spiracle, with smaller, sharp ones below. The thoracic legs are black; the middle abdominal legs large, greenish, with two or three alternating rows of sharp, black spines near the base, and also with fine, white tubercles like those on the rest of the body. Along the middle of the under side of the body the skin is immaculate green.

*Stage V and last.*—Length, 35-38 mm. (Jewett says from two to two and a half inches when fully grown). The head is now not angular but rounded, though slightly narrowing and produced above; dark pea-green, considerably darker than the body; with a broad, yellow band beginning on the antennae and fading out on the vertex. The ocelli are black; the mandibles black; the anterior lobes of the labrum brown, including the palpi. The head is about two-thirds as wide as the body, the surface covered with fine minute granulations arranged in groups (only seen under a strong, Tolles lens).

The body is thick; the prothoracic segment short, and not so wide as the second thoracic segment. It is unarmed; its front edge with a transverse series of white, bead-like warts set close together. Behind, the body is thick, being of the same thickness as far as the eighth abdominal segment. Second and third thoracic segments each with two pairs of very large spines, which are about two-thirds as long as the body is thick; the outer one of each pair is slightly shorter and slenderer than the inner, but those of both pairs are alike in size; they are roseate, pale coral-red and not so near in tint to the spines of the food-plant as in the young; when the

caterpillar is at rest they are held close together in a recurved position and in the grown-up larva when touched they are not moved or the body jerked in response to such stimulus. They are adorned with white, blunt spines, which are often tipped with black.

"The 'silver horns' on the third to the sixth abdominal segments are now one-sixteenth to one-eighth of an inch long, bright pink inside and burnished silver externally. The number of these 'silver horns' varies in different larvae, some having them only on the fourth and sixth abdominal segments; others have them on the fifth, seventh, and ninth segments; still others have them on the second, fourth, sixth, and seventh segments." (Papilio, II, 49.) "I have now to add that this year I reared three larvae having these silver horns on every segment except the twelfth; still the imagines from these three larvae did not differ from the ordinary form." (Jewett, Papilio, II, 144.)

The horn on the eighth abdominal segment is now only about one-fourth shorter and thicker than the thoracic spines, and is of the same color and structure, the spinules being conical, rounded, blunt, white, and bearing a fine bristle.

On abdominal segments 1-7 are two dorsal rows of acutely conical spines, which are recurved and directed backward. Those on the fourth and sixth abdominal segments are twice or thrice as large as those on the other segments (1-3 and 4 and 7), and provided with three or four blunt spinules; the spines themselves are roseate on the inner side, and externally brilliantly painted with a pearly silvery white, giving off all the colors of the rainbow during the movements of the animal. The corresponding spines on the other segments are painted in the same fashion, though less brilliantly.

I find, as did Jewett, that the number of the dorsal "silver horns" varies, one larva having but two pairs, one on the fourth the other on the sixth abdominal segment, while in another there is a pair on the second abdominal segment (fig. 3). The degree of specialization of these dorsal spines varies, but those of the first abdominal segment are always smaller than any behind, both in stages IV and V. This stage in armature differs from IV in the much shorter and stouter thoracic horns, and in the differentiation of the two or three pairs of dorsal abdominal silvery spines.

On the side of the body from the third thoracic horns to the eighth abdominal spiracle is a bicolored stripe; it is pure marble-white below, and above rosy purple, and is interrupted by the wax-colored spiracles, which extend above the upper limits of the reddish line. The suranal plate is very large and long, deeply divided at the end, the two forks being, like the surface, coarsely granulated with stout short conical spines; the plate is green, with the edge straw-yellow. There is a minute median spine on the ninth abdominal segment. Each abdominal segment with two dorsal transverse rows of white, bead-like, coarse granulations. Below the bicolored lateral stripe is a black, double, conical spine on each segment, and underneath on abdominal segments 1, 2, 7, and 8 is a group of unequal, smaller, black, sharp spines. The body beneath is granulated with white, and also on the sides, as well as above.

The thoracic legs are black, partly greenish beneath; the abdominal legs, including the anal pair, are greenish, with a group of singular black piliferous spines, while some of the spines are tipped with white.

The general color of the body is of nearly the same hue as the under side of the leaves of the honey-locust, and thus colored it is partly assimilated and protected by its color, while the horns are in general like the spines of its food plants. On the other hand, the gleaming silvery spines certainly render the creature conspicuous, as well as the lateral parti-colored band.

It would appear probable that the formidable spines of the grown-up caterpillar save it not infrequently from being swallowed by birds; though the horns are probably of greater use in the earlier stages, when they are much longer and much more movable, in frightening away ichneumons and Tachinae. For example, even when 20 mm. in length, a larva was seen when teased to spread apart its great arm-like horns, while the full-fed ones did not notice such stimulus.

SUMMARY OF THE SALIENT FEATURES IN THE ONTOGENY OF *ADELOCEPHALA BICOLOR*.A.—*Congenital characters of the larva, all appearing in stage I.*

1. The two pairs of enormous spines of second and third thoracic segments, one-half as long as the body, and ending in a two-spined, large, flattened, dark bulb; freely movable and plainly defensive in function.
2. The large, reddish, spiny "caudal horn," on the eighth uromere, ending in two bristles.
3. The double piliferous tubercle on the ninth uromere, becoming obsolete in stages IV and V.
4. The abdominal region is longitudinally striped with dark and whitish bands, but there are no transverse marks in stage I or in later stages.

B.—*Evolution of later adaptational characters.*

1. The head slightly angular, face subtriangular, with a light brown or greenish lateral stripe (stages II-V).
2. Appearance of a transverse row of dorsal granulations on the hinder end of each segment in stage II, persisting through larval life.
3. The eight thoracic spines lose their bulbous tips, and become simply slightly forked in stage III, and later.
4. The two dorsal spines of uromeres 1-7 are in stage II larger than the others; in stage III they become ivory-white externally, and in stage IV larger and silvery white on the outside.
5. In the last two stages the eight thoracic spines become very much shorter in proportion to the size of the body and become less movable; as they decline in size and functional importance, the metallic, silvery, dorsal spines on the abdominal segments become conspicuous and apparently useful to the larva.

One larva, 36-37 mm. in length, ceased feeding August 7, and began to pupate, but I did not carry any into the pupa stage.

What Doctor Jewett means by saying that "the larvae change only in size during the last moult," we do not understand, as the increase, so far as we have noticed, is gradual from stage I to V, as in other larvae. The brood which Doctor Jewett raised in Ohio "began to quit feeding on the 29th of June, entering the ground within a few hours after ceasing to eat. Then they pupated within an oval cell lined with a thin cocoon of silk, but first casting its skin on the 24th. The pupa is at first bright green, but changes to jet black in a few hours."

"Imagines began to appear on July 3, and had nearly all emerged by July 10. The insect is three-brooded here, hibernating in pupa. Although the large majority of each brood follows the cycle of development as described, yet a few of each brood are much slower in making their changes. Thus a few of the brood did not complete their growth till the end of July, and three pupae, formed June 26, are still alive (February 28), having hibernated. Other pupae of the same brood disclosed their imagines at various periods during July and August. This accounts for the fact that larvae in all stages of development may be found at any time throughout the summer till frost kills their food-plants." (Jewett.)

*The Sphingid affinities.*—This is the most Sphinx-like of any ceratocampid or other bombycid I know, resembling sphingid caterpillars in the following characters:

1. The shape of the head and its markings.
2. The shape of the body.
3. The caudal horn.
4. The large, square, heavy anal legs.
5. The skin granulated with small white tubercles.
6. The sphingid attitude.

One can, when we take into account the larvae alone, well imagine that the Sphinges are, as claimed by Mr. E. B. Poulton, descended from the Ceratocampidae. This view is also borne out by the structure and subterranean habits of the pupa, and the structure of the moth, as already stated.

*Pupa*.—(Pl. LVI, figs. 3, 4.) According to Jewett the pupa is at first bright green, but changes to jet black in a few hours. Body nearly cylindrical, the anterior extremity being nearly hemispherical and the posterior extremity tapering rapidly in the last two segments to a blunt point, which is extended into a bipronged spine three-sixteenths of an inch long. "The surface of the hemispherical portion is studded with minute, sharp, triangular points. Wing cases small, covering only the sides and under surface of the anterior one-third of the pupa. Four of the abdominal segments are separated by a broad, deep suture; the anterior and posterior margins of these segments are armed with a row of minute, sharp spines." Length, 24 mm. Without examples of the pupae of other species it is impossible to correctly define these of the present species.

The eggs (in Ohio) were deposited May 26 and hatched May 31 (Jewett).

*Food plants*.—Spiny locust (*Gleditschia triacanthos*); Kentucky coffee tree (*Gymnocladus canadensis*).

*Habits*.—The larvae in Ohio began to stop feeding June 20, entering the ground within a few hours after ceasing to eat. "There they pupated within an oval cell lined with a thin cocoon of silk, the first casting its skin on the 24th . . . Imagines began to appear on July 3, and had nearly all emerged by July 10. The larvae pupate readily on the bottom of the breeding cage if ground is not furnished them. In this case they build no cocoon."

"The insect is 3-brooded here, hibernating in pupa. Although the large majority of each brood follows the cycle of development as described, yet a few of each brood are much slower in making their changes. Thus a few of the brood did not complete their growth till the end of July, and three pupae formed June 26 are still alive (February 28), having hibernated. Other pupae of the same brood disclosed their imagines at various periods during July and August. This accounts for the fact that larvae in all stages of development may be found at any time throughout the summer till frost kills their food plants, which are *Gleditschia triacanthos* L. (honey locust or three-horned acacia) and *Gymnocladus canadensis* Lam. (Kentucky coffee tree)."

Walsh, referring to the fact that he never saw the larva of *Anisota senatoria* assume a sphingid attitude, states that that of *A. bicolor* invariably assumes this attitude in repose, "clasping at the same time the under surface of the main rib of the honey-locust leaf with its prolegs, so as to be overshadowed and concealed by the leaflets" (l. c., p. 294).

*Summary of the life history*.—The larva hatching May 31 lived four days before the first moult, which occurred June 4. The duration of stage II is four days; of stage III, five days; of stage IV, four days, and of stage V, and last, three days. Entering the earth to pupate, it remained in this state from twelve to thirteen days, the moths appearing from July 3 to 10. In southern Ohio it is 3-brooded and hibernates as a pupa.

#### ADELOCEPHALA QUADRILINEATA Grote and Robinson.

*Adelocepha quadrilineata* Grote and Robinson, Trans. Amer. Ent. Soc., I, p. 11, Pl. 1, fig. 2.—DRUCE, Biol. Centr. Amer., Lep. Het., I, p. 171, June, 1886; II, p. 414, Mar., 1897.

This rare species is very closely allied in the shape of the wings and markings to *A. bicolor*, but differs, according to Grote and Robinson, in the simple antennae and in the distinct lines of the upper surface of the fore wings.

*Geographical distribution*.—Jalapa, Coatepec, Orizaba, Mexico; city of Guatemala, Candelaria Mountains, Costa Rica (Druce). Dyar's List records it from the Mississippi Valley.

*Pupa*.—H. Edwards states that in shape it is very like that of *Anisota*, but a little longer in comparison. It is pitchy black throughout. The entire surface very rough, and covered with minute raised spinés. The two rows of teeth on five last abdominal segments well marked. On top of the head, first segment behind the head case, are two raised, shining, large, black tubercles. The cremaster is very long, bifurcate, and extremely rough. Length, including the cremaster, 54 mm.; width, 16 mm. (Ent. Amer., IV, p. 62).

## ADELOCEPHALA BISECTA (Lintner).

Pl. XX, fig. 13♂, 14♀.

*Anisota bisecta* LINTNER, Can. Ent., XI, p. 10, 1879.*Sphingiacampa bisecta* var. *nebulosa* NEUMÖGEN, Ent. Amer., VI, p. 63, 1890.*Sphingiacampa bisecta* KIRBY, Syn. Cat., Lep. Het., I, p. 740, 1892.—NEUMÖGEN AND DYER, Journ. N. Y. Ent. Soc., II, p. 149, Dec., 1894.*Syssphinx bisecta* DYAR, Proc. Ent. Soc., Wash., IV, p. 428, May 13, 1901.

## Larva.

Jewett, H. S., Papilio, II, p. 38, Mar., 1882.

*Imago*.—♂ Antennae of ♂ with shorter and broader joints, and a little longer pectinations than in *A. bicolor*; the distal third filiform, and without the short vestigial pectinations of that species. The front of the head is a little wider than in *A. bicolor*.

Fore wings with the costa straighter, the outer edge oblique, its course straighter, not so full; hind wings shorter and rounder than in *A. bicolor* and not reaching so near the end of the abdomen as in that species.

Body and wings rather pale in hue, ocherous; the thorax with a slight pinkish hue in the middle; abdomen paler, uniform ocherous.

Fore wings without any distinct discal spot, only a very faint oval elliptical ring. The wing is inside the extradiscal line nearly uniform ocherous, with but few dark specks or strige, and those minute and inconspicuous. Extradiscal line oblique, firm, not wavy or sinuous, a little incurved on the costal edge before reaching the apex; the line is pale brown, edged externally with pink, and the pink extends to the edge of the wing, including the fringe.

Hind wings rounded at the apex, full on the outer edge, and rounded at the inner angle; ocherous, pink toward the base and inner edge, while the costal region and the outer third or fourth is ocherous.

Under side of fore wings as above, but paler, the extradiscal oblique line is distinct and the wing is pale ocherous within and pinkish beyond it, the wing also is pale ocherous toward the costa and pink toward the inner edge. A large diffuse double smoky discal spot, not present in *S. bicolor*. Hind wings pale ocherous, with coarse dark specks toward the costa, the rest of the wing clear of them; outer margin ocherous, becoming paler toward inner edge; a faint extradiscal curved line which tends to fade out toward the inner edge. Legs dull pink red.

♀ Antennae simple. Fore wings rounded, full, much as in *A. bicolor*, but more rounded on outer edge; hind wings rounded at the angles and excised, costally more than in *A. bicolor*, without spots and with no median band, fore wings beneath with a diffused brown discal spot. It is paler ocherous, with a more distinct extradiscal line than in any other North American species.

Expanse of fore wings, ♂ 55 mm.; length of a fore wing, ♂ 26 mm.; breadth of a fore wing, ♂ 13 mm.; length of hind wing, ♂ 17 mm.; breadth of hind wing, ♂ 13 mm.

Resembles in shape of wings and head the Brazilian *A. solangulata* more than any other North American species. For the genital armature see Pl. LIX, figs. 2, 2a.

Var. *nebulosa*, ♀. The extradiscal line very distinct, blackish brown; discal spot prominent, suffused with blackish brown grains. Hind wings of a rich yellow, with a beautiful roseate basal hue, fading toward the center.

In the Neumögen collection is an unnamed pair from Brazil of the size and shape of *A. bisepta*, but ♀ much like *A. bicolor*. It seems to represent *A. bicolor* in South America.

*Larva*.—Dr. H. S. Jewett briefly refers to the larva, as follows: "A larva found by a friend (by bushbeating) in company with *bicolor* larvae, having no silver horns, but only the rudiments on one segment, but otherwise resembling *bicolor* larva so closely that he supposed it to be only larval variation, disclosed ♂ *Anisota bisepta* Lint." Papilio H, p. 40 (footnote), 1882.

*Geographical distribution*.—Austroriparian passing up into the Appalachian province: Racine, Wis. (Hoy); Columbus, Ohio (W. N. Tallant); Kentucky (Doll); Texas (Meske, Neumögen). It has not yet been detected north of Kentucky and central Ohio (lat. 40°) nor along the Atlantic coast. (See Map II.)

## ADELOCEPHALA HEILIGBRODTII (Harvey).

(Pl. XIX, fig. 5 ♂.)

*Anisota heilighbrodtii* HARVEY, Can. Ent. IX, p. 110. June, 1877.*Sphingicampa heilighbrodtii* KIRBY, Syn. Cat. Lep. Het., I, p. 740. 1892.—NEUMEGGEN and DYAR, Journ. N. Y. Ent. Soc. II, p. 149. Dec., 1894.*Syssphinx heilighbrodtii* DYAR, Proc. Ent. Soc. Wash., IV, p. 428. May 13, 1901.

*Imago*.—1 ♂. Antennae ♂ bipectinate, filiform on the outer third, with fine sete instead of vestigial pectinations or teeth. Head and prothorax blackish; front of the head rather broader than usual. Thorax gray behind, slashed with blackish.

Fore wings rather short and broad compared with the other species; costa straighter than in *A. bicolor*, but not so much so as in *A. bisecta*, apex somewhat rounded, and outer edge moderately convex, nearly as long as the inner edge, which is more convex than in *A. bisecta*. In hue uniformly iron-gray or hoary brown, including the fringe, with no distinct lines, but a minute white discal dot, with sometimes traces of a second or twin dot.

Hind wings short and much rounded, not reaching so far back as in *A. bicolor*, more as in *A. bisecta*, not reaching much over one-half way beyond the middle of the abdomen, which is rather long. In hue dull dark pink, gray-brown on the costal and on the outer edge; inner edge pink; fringe gray-brown; wings dusky pink at base. Discal spot large, round (2 to 2½ mm. in diameter).

Under side of fore wings dusky in the middle, dull pinkish along the veins; an indistinct extradiscal brown line; costa gray. No discal spot.

Hind wings gray, with a slight pinkish hue, paler toward and along the outer edge. A large round black discal spot. A faint diffuse extradiscal line disappearing toward the costa and inner edge. Abdomen gray, with a faint ruddy tint.

Expanse of the fore wings, ♂, .55 mm.; length of one fore wing, ♂, .28 mm.; breadth of one fore wing, ♂, .14 mm.; length of a hind wing, ♂, .21 mm.; breadth of a hind wing, ♂, .15 mm.

This species may be recognized by the fore wings being unusually rounded, by the obtuse apex, the hind wings being also rounded. For the venation see Pl. XXXVIII, figs. 2, 2a. Another distinctive mark is the dark gray or hoary brown fore wings, with the absence of distinct lines. The hind wings are dull pinkish, with a large black discal spot above and beneath.

*Geographical distribution*.—Bastrop County, Tex. (Heilighbrodt tide Meske); New Mexico (Strecker). So far as known this moth is confined to central Texas and the southern portion of New Mexico and Arizona.

Arizona (Neumegen?). It has not yet been detected in Mexico or any other part of Central America. (See Map III.)

## ADELOCEPHALA ALBOLINEATA Grote and Robinson.

(Pl. XIX fig. 1 ♀.)

*Adelocephala albolineata* GROTE and ROBINSON, Proc. Ent. Soc. Phil., VI, p. 7, pl. 1, fig. 7 ♂. 1866.*Adelocephala raspa* BOISDUVAL, Annales Soc. Ent. Belgique, XV, p. 93, Pl. III, fig. 1. 1872.*Adelocephala albolineata* DRUCE, Biologia Centr. Amer. Lep. Het., I, p. 171. June, 1886.*Sphingicampa albolineata* KIRBY, Syn. Cat. Lep. Het., I, p. 740. 1892.—NEUMEGGEN and DYAR, Journ. N. Y. Ent. Soc. II, p. 150. Dec., 1894.

*Imago*.—1 ♂, 1 ♀. Antennae? (wanting). Head of moderate size, wide in front, narrowing to a point at the labrum. Maxilla (in ♀) comparatively well developed, very slender, about as long as the front is broad across the middle.

Head, thorax, and fore wings lemon-yellow-ocher, being brighter ochreous than usual. Edges of the tegulae white, forming two conspicuous diverging white lines, edged within with pale, pearly gray, the hairs on the sides of the thorax at the base of the wings being of the same gray hue.

Fore wings rather broad; costa straight, becoming arched toward apex, which is obtuse; outer edge full and convex, inner angle well rounded. Hind wings broad, apex not much pro-

duced, outer edge full; the wings not reaching to the end of the abdomen in either sex, though near it.

Fore wings lemon-ocherous in ♂, darker, with an olive tint in ♀; basal line broad, very distinct, snow white, much curved, beginning not on the inner edge, but at a point between that and the costal edge of the wing and sweeping around so as to end on the costa a little before the middle of the wing, and nearly touching the extradiscal line between veins IV and VI. Extradiscal line snow white, broad, a little sinuous, extending from a point inside of the middle of the inner edge to the apex, or nearer to it than in any other species. A small white discal dot. Fringe, white.

Hind wings pale roseate in ♂, with the outer edge lemon-ocherous; fringe luteous or clay-gray. In ♀ the entire wing is uniformly deep roseate and the fringe is white. A very slight diffuse, dusky, discal discoloration. Extradiscal line curved, diffuse, arising on the middle of the outer edge and ending before the apex.

Under side of fore wings paler than above, with a more faded appearance; no lines except faint indications: an irregular, squarish, smoky, dark discal spot. Hind wings of the same hue with an irregular oval dark discal spot a little smaller than that on the fore wings. Underside of ♀ whitish gray, washed with pink in the middle of the wings. A large diffuse blackish irregular discal spot. Hind wings the same, but the costal edge whitish, and discal discoloration smaller than on fore wing. Extradiscal line whitish, quite indistinct.

Abdomen lemon-yellow in ♂, in ♀ dull grayish pink, though lemon-yellow at base. Legs: femora and tarsi grayish; a little dusky in ♀. Tibial sack dark, leaf-shaped, acute, one-half as long as the tibia itself, covered externally with hair-like scales.

Expanse of wings, ♂, 70 mm.; ♀, 75 mm. Length of a fore wing, ♂, 40 mm.; ♀, 38 mm. Breadth of a fore wing, ♂, 19 mm.; ♀, 19 mm. Length of a hind wing, ♂, 24 mm.; ♀, 25 mm. Breadth of a hind wing, ♂, 19 mm.; ♀, 20 mm.

A very gaudily marked and striking moth: the white lines on the thorax and fore wings and the white fringe rendering it a very conspicuous and handsome insect.

*Geographical distribution.*—Thus far only known from the eastern tropical coast belt of Mexico. Jalapa, Mexico (O. T. Barrett, H. Edwards); Oaxaca (Boisduval); City of Mexico, (Höge); Oaxaca, "apparently rare" (Drury).

#### ADELOCEPHALA MONTEZUMA sp. nov.

(Pl. XIX, fig. 6; XXXVII, figs. 3, 3a; LXI, fig. 3.)

This is perhaps the largest and finest species yet known from Central America.

*Imago.*—2♂. This species is very near the Brazilian *S. fallax* ♂, but differs in the discal spot being small, white, and in the presence of an extradiscal line on the hind wings, while the extradiscal line on the fore wings is not slightly curved, but straight in its course; otherwise the figure represents very well my specimen. It is smaller than *S. jason*, which has a brown discal streak. The scalloped outer edge of the hind wings indicates that the species has undergone a considerable degree of specialization.

Body and wings of a rich deep reddish-orange yellow, less ocherous than usual in the genus. Head with the front triangular, narrowing rapidly toward the labrum. Eyes rather large. The shape of the head and wings almost exactly as in *A. subangulata*, but in the undraped example I can see no maxilla or labial palpi. The abdomen is pointed at the tip and with a lateral tuft on each side just before the end, much as in *A. subangulata*. The central disk of the thorax is ocherous, the edge of the tegulae pinkish.

Fore wings with the costa straight, a little curved toward the apex, which is sharper than usual; outer edge straight, not convex, oblique, and very slightly scalloped; outer edge of the same length as the inner. (In *A. subangulata* the outer edge is decidedly shorter than in the present species.) Base of wing on the hinder half pink within the basal line. This line is oblique, but not curved or sinuous. The extradiscal line arises well beyond the middle of the inner edge

and passes directly, without curving, to the costa ending near the apex; both lines dark brown; veins of the same brown hue beyond the middle of the wing; outer edge of the wing and fringe pinkish, and also the inner edge as far as the extradiscal line.

Hind wings not reaching to the tip, only as far as the outer fourth, with a distinct but small oval white dot at the outer and hinder angle of the discal area, and with a dark discoloration in front. The wings are deep reddish-pink, almost brick-red at base and along the inner edge, but the costal and marginal regions and inner angle are deep orange-ocherous. An extradiscal brown line, not so distinct and dark as on the fore wings. In shape the hind wings are near those of *A. subangulata*, but with a more decided inner angle, and the outer edge is slightly scalloped toward this angle; apex well rounded. Beneath, the fore wings are deeper orange-red than above in the middle of the wing, but becoming ocherous toward the apex; beyond the extradiscal line of the same hoary pale-pinkish hue as the hind wings; a large blackish irregularly oblong discal spot; hind wings with no discal spot and with dark strige. Legs rose pink; tibiae ocherous externally; the tibial sack (pl. XXXVI, fig. 13) is rather large and broad, two-thirds as long as the tibia itself, and concealed under it when the leg is folded to the breast; tibiae with no spines.

*Geographical distribution*.—Central America: Jalapa, Mexico (O. T. Barrett).

Expanse of fore wings, ♂, 100 mm.; length of a fore wing, ♂, 45 mm.; breadth of a fore wing, ♂, 23 mm.; length of hind wing, ♂, 30 mm.; breadth of hind wing, ♂, 20 mm.

#### ADELOCEPHALA HÖGEI Druce.

(Pls. XIX, fig. 4; XXXIII, fig. 3.)

*Adelocephalia högei* DRUCE. Biologia Central. Americana, Lep. Het., I, p. 172. Tab. XVI, fig. 9. ♂. 1886.—KIRBY, Syn. Cat. Lep. Het., I, p. 742. 1892.

*Iuago*.—4 ♂. In the shape of the wings and markings allied to *A. bisecta*, though with the discal spot as in *bicolor*. Antennae as in *bisecta*; 20 pairs of pectinations, and the filiform tip with about 22 joints. Fore wings with the costa straight, apex subacute, rectangular, outer edge as in *bisecta*, not so full and convex as in *bicolor*. Hind wings as in *bisecta*.

Fore wings deep brownish ocherous as in *bisecta*, outer edge with brown flecks; inner edge of the wing bathed with pink. The two lines brown, distinct, the basal one nearly straight, bent out a little on the median (cubitus) vein. Extradiscal line firm, distinct not wavy, and as in *bisecta*, ending on the costa just before the apex.

Hind wings nearly all deep rose pink, paler on the costal and outer edge, no transverse lines; two snow-white, discal, irregular, triangular spots varying in shape and size, the two sometimes being confluent, the anterior one being always the smaller of the two.

Beneath, the fore wings with a large, black, discal spot centered with an obscure whitish lunule. Behind it the wing is dull pink; beyond it, toward the apex, the wing is ocherous brown as above; edge of the wing beyond the extradiscal line bathed with pale pink. Hind wings dull pale pink, with faint traces of an extradiscal line. Legs dull pink.

Expanse of the fore wings, ♂, 55 mm.; length of a fore wing, ♂, 30 mm.; breadth of a fore wing, ♂, 15 mm.; length of a hind wing, ♂, 20 mm.; breadth of a hind wing, ♂, 15 mm.

*Geographical range*.—So far as yet known, this species is confined to southeastern Mexico and Yucatan; Valladolid in Yucatan (Gaumer), Jalapa (Höge), Vera Cruz (Franck).

*A. högei*, var. *montana*. In the museum of the Brooklyn Institute, Mr. Doll kindly showed me two specimens from "among the mountains" near Guadalajara. It is of the size of *A. högei*; the white discal spot the same as in *A. högei*; the middle of the wing is clear yellow, base and outer edge lilac gray. Hind wing with the outer edge yellow; there are no spots on the wings. The under side of the wing is as in *A. högei*, but without any spots or stripes. In one ♂ the two discal white spots are blended into a single irregular one.

*A. dollii* sp. nov. Another species in the Brooklyn museum, from Mexico, is a little larger than *A. högei*; the body and wings are uniformly reddish brown as in *Anisota stigma*, with a lilac tinge, and with no stripes. The basal line is very indistinct; the extradiscal line regularly curved and ending on the apex. The discal spot is minute, white. Beneath there is no discal spot; there is a faint extradiscal line common to both wings. It seems to have been undescribed.

#### ADELOCEPHALA ISIAS Boisduval.

(Plate XXXIII, fig. 1, ♂ and ♀.)

*Adeloccephala isias* Boisduval, Annales Soc. Ent. Belgique, XV, p. 92, 1872; KIRBY, Syn. Cat. Lep. Het., I, p. 742, 1892.

*Imago*.—1 ♂, ♀. This species has been found by Mr. Jacob Doll at Brownsville, Tex., and identified by Doctor Dyar. It is so closely allied to *A. högei*, that that species will probably be united with it, since the only important difference is the greater number of pairs of pectinations to the male antennae. The male genital armature should be examined to test the specific distinctness of *A. högei* from this species.

The front of the head in the ♀ comes to a point, the front being decidedly triangular, narrowing rapidly toward the labrum; in the male the front is wider at the labral region, and the thickened projection of the clypeus is visible.

Male antennae with 21 pairs of pectinations, the simple tip consisting of about 20 joints, while in four ♂♂ of *A. högei* there are only 18 pairs of pectinations, the filiform extremity being 18-jointed.

It is very near *A. högei* ♂ in the shape and color of the head, thorax, and abdomen, in the shape of the wings; the presence of two white discal spots, and the style of coloration, the chief difference being the pearl-gray tint of the fore legs, and the duller ocherous ground color of the wings.

*Male*.—Head and body ocherous, but not of so bright a tint as in *A. högei*. Fore wings of the same shape, costa and outer edge the same, but the outer angle is more angular, less rounded, than in *A. högei*, while the ground color of the fore wings is more gray ocherous; the base of the wings and their outer edge are washed with pearl gray rather than pink. The two cross lines the same in direction and width, but instead of being distinct and dark reddish as in *A. högei*, they are somewhat indistinct and inclined to be dark brown. The two separate white discal spots of *A. högei* are in *A. isias* represented by two much larger white spots which are very nearly connected (at first sight they appear to be so); the larger spot is irregularly rhomboidal or diamond-shaped, twice as long as wide, pointed at each end, and very slightly separated from the one in front, which is about one-quarter as wide as the other, and pointed at the outer end. (In four *A. högei* ♂, the two spots are small and usually separated, but in one example they are confluent.)

Hind wings as in *A. högei*, except that they are paler, duller in hue, but the roseate patch is the same. Beneath, body and wings of a decidedly duller, more grayish hue than above, but identical in tint with some of the *A. högei*; the fore wings are the same as in the other species. The large black round discal spot is centered with whitish or pearl-gray scales exactly as in *A. högei*, the latter varying a little. The fore legs differ from those of *A. högei*, which are pink, in being grayish pearl.

All the slight difference from *A. högei* we have pointed out we believe to be varietal, except that of the antennae. Its specific distinction or identity may be settled hereafter by an examination of the genital armature. From Boisduval's description of his ♂ the two white discal "points" appear to be like those of *A. högei*.

*Female*.—The antennae are simple, with no vestiges of the male pectinations; slightly ciliated on the distal half. In markings and shape of the wings very different from the ♂; fore wings with no white distal spots, but instead is a large round dusky brown spot, while the ground color

of the wing is a fawn gray; the hind wing as in  $\delta$ ; in the fore wings the two lines and fringe are dark brown, and the surface is distinctly striated; the dark round discal spot is about one-half as wide as the space between the two lines.

Beneath, a little less roseate, the black round discal spot as in  $\delta$ . The outer line on the hind wings is more distinct than in *A. högei*, though it disappears in the middle of the wing. All the legs are decidedly a pearl-gray and with the costa of the wings concolorous in both pairs.

Expanse of the fore wings,  $\delta$ , 51 mm.;  $\varphi$ , 60 mm. Length of one fore wing,  $\delta$ , 25 mm.;  $\varphi$ , 30 mm. Breadth of one fore wing,  $\delta$ , 13 mm.;  $\varphi$ , 15 mm. Length of hind wing,  $\delta$ , 12 mm.;  $\varphi$ , 20 mm. Breadth of hind wing,  $\delta$ , 12 $\frac{1}{2}$  mm.;  $\varphi$ , 15 mm.

Although the hind wings of the  $\delta$  are not triangular as in *A. wardii*, etc., yet the equality in size of the larger dorsal spines of the thoracic and abdominal segments of the larva shows that this is the most primitive of the Central American forms. *A. högei* will probably be found to be a synonym of this species.

*Larva* (Pl. III, figs. 2, 2a XLIX, figs. 3, 3a).—A blown example of a remarkably beautiful larva of this genus was collected by Mr. Jacob Doll at Esper Ranch, Brownsville, Tex., in the spring of 1903, and I am indebted to him for the privilege of having it drawn by Mr. Joutel and described. It differs remarkably in coloration, but belongs to the same section of the genus as *A. bicolor*.

Length, 51 mm. Body rather thick. Head a little more rounded, not so high and narrow above as in the other Texan (San Antonio) larva, which may be a variation of this species. The head is pea green, but above the clypeus and on the sides of a glaucous green; no lateral stripe is present.

Prothoracic segment with the tubercles on the front edge of the same shape and size, forming rounded smooth bosses, the two dorsal ones very slightly larger than the other.

The eight thoracic horns of equal size and length, shorter than in the San Antonio larva, much shorter than the body is thick, with low slightly marked rounded spinules, which are much less prominent; the horns are recurved and are deep pink, green at the tip.

The spines of the dorsal series (7) on abdominal segment 1 are minute and short, cherry red; they are much reduced in size compared with those on segments 2, 4, and 6; no higher than broad. On abdominal segments 2, 4, and 6 the dorsal tubercles are large, stout, flattened, conical, cherry red on the inside, and externally porcelain white. Those on segment 6 are a little larger than the others. Those of the subdorsal row (on segments 4, 6, and 7) are about two-thirds as large as those of the dorsal series.

On abdominal segments 4 and 6 a yellowish streak connects the spiracle and subdorsal spine.

Caudal horn short and stout; not so long and large as in the San Antonio larva; bearing low, rounded, not prominent, tubercles. The horn is cherry red on the basal half, and beyond green to the end.

Suranal plate with a single row of large yellowish-green bosses on the edge, not crowded as in the San Antonio larva. Spiracles pale sienna brown. A lateral lilac line shaded beneath with yellowish green.

This is a wonderfully beautiful caterpillar, and differs from any other known species in the bright cherry-red tubercles, which externally are porcelain white, not like burnished silver or gold, as seen in *A. bicolor*, etc.

It is perhaps a later form than *A. bicolor* and its allies, and appears to have undergone a slightly greater modification in its style of coloration.

The larva here figured and described has been referred to *A. isias* by Doctor Dyar, this being the only other species known to inhabit both Arizona and Texas.

The pair figured on Plate XXXIII was raised from the larva by Mr. Jacob Doll and identified as *A. isias* by Doctor Dyar, and I find it will agree with Boisduval's description.

Two larvae collected by Mr. Jacob Doll at Brownsville, Tex., in April, 1902, when compared with those from San Antonio differ decidedly in the broader, more triangular abdominal dorsal and subdorsal spines, while there are much fewer granulations; also the caudal horn is a little shorter.

The specimen kindly sent me by Dr. R. E. Kunzé from Phoenix, Ariz., though it is deprived of its head, agrees with my figure (2) of the larva of *A. isis*. It differs in respect to the armature from my drawing on Pl. XLIX, figs. 3, 3a, in the following respects: The thoracic horns are provided with more spinules, which are not confined to the base, but are scattered along nearly to the tip of each horn; the spines on abdominal segment 1 are larger, and but slightly smaller than those on segments 2-7. As regards segments 8-10 my larva agrees well with my figure 2e, (Pl. XLIX) though the dorsal tubercles on segment IX are larger.

Doctor Kunzé has been obliging enough to send me the following description of the living larva collected by him:

Description of larva: In general appearance the larva reminds one of a young *Ctheromia regalis*.

Face oval, green, a white line each side of triangular space and next to that a narrower black line of obovate shape. Mouth parts blackish. On first segment a diadem of silvery granulations from spiracle to spiracle; all of which latter are black throughout. On second thoracic segment are two spinose tubercles, 6 mm. long, on each side, four in all. On third thoracic segment are four tubercles, two on each side, spinulated like the others, and 6 mm. long. The dorsal tubercle is purple or violet, and the lateral one of apple green throughout. Spinules of dorsal tubercle black, spinules of lateral one green. Segment 4 and inclusive of 11, have on each side one above the other, two silvery, short tubercles, the upper of cuneiform shape, of which the inferior rests on the infraspiracular line. The inner side of these silvery tubercles is bright red. A crescent of silvery granulations, just back of the tubercles of each segment 4 to 11. On the penultimate segment (12), a spinulated tubercle, 4 mm. long, reddish brown at base, green at tip, spinules whitish at base and green above. Three small silvery tubercles on last segment above anal plate. Dorsal and lateral surface smooth, apple green. Abdominal parts concolorous. Prolegs much granulated from base to feet, the granulations green. Thoracic legs, green, the base only with green granulations. Infraspiracular line pink, with lilac reflections. Spiracles black. Between the silvery dorsal tubercles of each segment, two silver granulations. The anal plate is lined by a triangle of white granulations. Clasper of the prolegs brownish.

Length of larva at rest, September 30, 1904, 11 $\frac{1}{2}$  inches (29 mm.); length of larva in motion, September 30, 1904, 14 inches (32 mm.); width of larva  $\frac{1}{8}$  inch September 30, 1904 (5 mm.).

Found on *Parkinsonia microphylla*, September 28 and 29, 1904, Phoenix desert, Arizona.

*Last stage of Sphingiacampyl larva—Adelocophala isis*.—Found on a mesquit tree (*Prosopis juliflora*), October 24, 1904, in the garden of Dr. R. E. Kunzé, Phoenix, Ariz.

Antennae whitish, mouth parts brownish. The lateral thoracic tubercles on the second and third segments white and but little spinose. Dorsal thoracic tubercles pink, tipped white, and green at the base, equally so, but little spinose. The small cuneiform, silvered and pink-tipped tubercles on the segments of dorsal row 2 mm. long. Those of the subdorsal row 1 $\frac{1}{2}$  mm. long, the points of all silvered. The tubercles had an upward direction. The spinose tubercle on the penultimate segment pink, tipped white, and green at base. Infraspiracular line violet lavender; spiracles black, edged with white. Thoracic feet green, claws brownish. Abdominal feet green at the base; hooks brownish. General color an apple green. No other changes observable. Length at rest, 45 mm.; length in motion, 54 mm.; average diameter of segment, 8 mm.

*Food plants*.—*Parkinsonia microphylla*, native name "Palo Verde," and mesquite tree (*Prosopis juliflora*). (Dr. R. E. Kunzé). At Brownsville, Tex., it was found by Mr. Doll on the Mexican ebony (*Acacia flexicaulis*).

*Geographical distribution*.—While this species was first detected within the limits of the United States at Brownsville in southeastern Texas, near the mouth of the Rio Grande, a few miles south of latitude 26° N., and opposite Matamoras, Mexico, it was next discovered at Phoenix, Ariz., and its geographical range almost exactly coincides with that of *A. heilibrattii* (see map III), though it has not yet been detected in New Mexico. In Central America it was collected, in the State of Jalisco and Costa Rica (Druse); Mexico (Boisduval).

*Habits of the larva*.—For much that we know of the transformations and habits of this fine species we are indebted to Doctor Kunzé, who wrote under date of October 5, 1904.

During the latter days of September he camped for three days on the Phoenix desert near the mountains around Prescott, Ariz., and was fortunate enough to detect a beautiful larva feeding in the hot sunshine on *Parkinsonia microphylla*, or "Palo Verde" of the natives. The following day he found a second specimen half a mile further away, but no others.

I looked carefully for a whole day or more, but could not detect another such, which are readily observed from the two rows of silvery tubercles as bright as a mirror, glistening in the sun like gems. Fortunately I succeeded in finding the larva with a much larger-leaved species, *Parkinsonia torreyana*, the leaflets of which are the size of the head of a shawl pin. I mailed these larva to Mr. L. H. Jontel, of New York, at once and trust he received one or both alive for figuring. I am sending him every three or four days a tin box of the food plant, because *Parkinsonia* is a subtropical plant, and I know of only two species.

He again wrote October 29 that he found a full-grown caterpillar on the Mesquite (*Prosopis juliflora*), which pupated the following day, burying themselves in his garden plot. On the 26th October he again went to the desert and found four more of the same larvae on *Parkinsonia microphylla*. All were fully grown, and the smaller one was sent to me.

I have collected on that desert for nine years, and am positive that this larva did not previously make its appearance in this locality. Palo Verde trees have very scant foliage, and are easily looked over, so that a larva of such beautiful ornamentation could not escape mine eyes.

In Brownsville, Tex., it was observed by Mr. Doll from the end of April until late in the summer.

I add a description of the San Antonio larva, which appears to be a form of *A. isias*. Mr. Joutel tells me that he is quite sure that all the larvae of this species figured on Pl. III are variations of *A. isias*. The more specimens I examine the greater seems the range of varieties in the length of the thoracic and abdominally spines, and in the degree of granulation of the skin. Such an amount of variation seems to indicate the primitive nature of this genus, and its comparatively recent adaptation to spiny food plants.

*Larva* (Pl. III, fig. 2, 2a; XLIX, figs. 2, 2a, 2b, 2c, 2d).—I have been able to examine through the kindness of Dr. H. G. Dyar a well-blown larva in the U. S. National Museum from San Antonio, Tex., the food plant of which is unknown. He thinks it may be that of *A. heliobrodtii*, and this seems probable. Unfortunately no specimens of this species have yet actually been bred from the larva.

Length, 50 mm. The head (Pl. XLIV, fig. 14) is as in *A. bicolor*, but slightly higher; pale bluish green, extending from in front of the eyes up to the vertex. On the front edge of the prothoracic segment is a series of low rounded porcelain white tubercles, which are much as in *A. bicolor*, but larger; they are nearer together, crowded, on the sides; and lower down are two small tubercles on each side above the spiracle.

The dorsal thoracic horns are longer than in *A. bicolor*, being nearly as long as the body is thick, much less curved than in the Brazilian species, but more so than in *A. bicolor*; they are not very sharp, and are armed with a few rather sharp spinules on the posterior side. As usual the subdorsal horns are a little shorter than the dorsal ones; all are green at the base, becoming roseate towards the middle.

The dorsal spine of abdominal segments 1 to 7, *all of the same size*, sharp, recurved, saber-shaped, porcelain-white, becoming roseate at the tip; they are smooth except those on the 7th segment, which are armed behind with a few fine teeth. The spines of the supraspiracular series (77) a little shorter, and as usual less prominent than those of the dorsal series. There is a series of small almost minute acute white infraspiracular tubercles (*i+r*).

The body is coarsely granulated. The porcelain-white tuberculets are larger and more prominent than in *A. bicolor*. There is a group on the first thoracic segment below the spiracle, and a larger group of still larger ones at the base of the thoracic legs. The sides of the second and third thoracic segments are densely granulated, while on each of abdominal segments 1 to 7 there are two transverse rows above the spiracles, and a group above the base of the legs. The abdominal legs are also granulated, there being more on the fourth pair than on those in front of them.

The caudal horn (fig. 2c) is not so stout as in the Brazilian larva, but longer and thicker than in *A. bicolor*. The spinules on it are much more numerous than in the Brazilian larva, and each ends in a minute short seta.

On abdominal segment 9 is a low porcelain-white median tubercle, conical, recurved.

Suranal plate (fig. 2e) rounded at the end, not deeply cleft, with a double row of crowded tubercles or granulations around the edge; and at the extremity not a pair of tubercles, but several small crowded granulations.

Anal legs with setiferous granulations crowded around the edges, the central field smooth except two or three small granulations, some of them long digitiform, but rounded at the tip.

Body in the dry specimen pale green, with a yellowish tint. A lateral bright conspicuous deep line, scarlet above and whitish beneath, extends from the hinder edge of the third thoracic to the ninth abdominal segment.

A larva of this species, evidently in stage IV, was collected at Brownsville, Tex., by Mr. Jacob Doll. We add a description of it.

*Stage IV* (Pl. III; fig. 2a).—Length, 30 mm. The head is as in the fully grown larva above described, but in the blown specimen it is not so green, and the lateral yellowish line is not so distinct, though more yellow towards the base of the antennae.

It differs in this from the last stage in the prothoracic tubercles being a little longer in proportion. The eight thoracic horns are slenderer, with decidedly longer spinules, which are mostly black, the tips rounded. The dorsal and subdorsal spines are much as in stage V in size; they are white externally and pale reddish on the inside along the middle, the ends being white. On the sides of abdominal segments 2, 4, 6, and 7 a yellowish streak connects the subdorsal spines with the lateral reddish line.

The caudal horn is now not so long as the body is thick, being a little shorter in proportion than in the fully grown larva; it is erect, thick at the base, and the rather crowded spinules bear long setae.

The suranal plate does not bear on the edge so many or so crowded tubercles as in the final stage (fig. 2d). The integument bears a few scattered minute white tubercles, but not nearly so many as after the last molt.

A lateral dull Venetian red line, shaded on the lower side with yellow. The general hue of the blown specimen is yellowish green.

Two specimens from Tucson, Ariz., collected by Charles Bendire, and now in the Museum of Comparative Zoology, Cambridge, Mass., were compared with the San Antonio blown larva. They agree with it in the slenderness of the dorsal and subdorsal abdominal spines, and in the numerous secondary tubercles or granulations on the sides of the segments. The eight thoracic horns and the caudal horn are nearly identical, though the spinules on the latter are slightly shorter than in the San Antonio example. There seems no doubt at all that the larva from these two localities are of the same species.

Of the two Tucson larva one has more lateral secondary tubercles than the other.

In the Tucson larva the thoracic and caudal horns are decidedly cherry red, with the tips paler.

In two examples from Brownsville there is some variation in the size and length of the spines of abdominal segments 1-7. The caudal horn is a little shorter than in the U. S. National Museum specimen, as are the dorsal abdominal spines.

The suranal plate is the same in the size and number of the tubercles. The two Brownsville examples differ among themselves, the dorsal and caudal horns being shorter in one than the other.

The larva of stage IV is represented on Pl. III, fig. 2a; also the details of the armature on trunk segments 1-6, on Pl. XLIX, figs. 2; the caudal horn and suranal plate at fig. 2d. Figs. 2a, 2b, and 2c represent the armature of the last stage; 2e a tergal view of the suranal plate.

#### ADELOCEPHALA BOISDUVALII Doumet.

*Adelocephala boisduvalii* Doumet, Revue et Mag. Zool., 1859, p. 266 (♂).

*Othorene mexicana* Boisd., Ann. Soc. Ent. Belge, XV, p. 84.

*Adelocephala boisduvalii* Drury, Biol. Centr. Amer. Het., I, p. 171. June, 1886.—Pl. —, fig. —. Kirby, Syn. Cat. Lep. Het., I, p. 741. 1892.

*Imago*.—1 ♂. A large species, larger than *A. högei*, with the apex of the fore wings more acute, the costa straight, the outer edge less full, more oblique than in *A. bisepta* and *A. högei*. The antennae are slightly wider than in *högei*; about 20 pairs of peetinations, and 25 short ones on the filiform tip. Head, body, and wings uniformly bright lemon yellow, with no dark spots or stigma. Fore wings with no distinct basal line; the extradiscal line very oblique, not wavy, narrow, brown, and ending on the apex of the wing. Two discal spots, snow-white, the hinder one subtriangular or distinctly triangular; the anterior spot smaller (nearly obsolete in my example). The base of the fore wings is a little pinkish, and the fringe is pale lilac on the outer and inner edges.

Hind wings with the apex rounded, but the outer edge is very slightly concave, giving a squarish appearance to the wing not present in any species except *A. montezuma* and *Syssphinx molina*. Colored like the fore wing, but with a large patch of deep pink behind the submedian vein ( $a_2r_1$ ), and not reaching either the outer or inner edge of the wing. Beneath, of the same lemon-yellow hue as above, a moderately large black discal spot, with an irregular eccentric white spot between it and the base; behind the median vein a pink-red patch. Extradiscal line distinct toward the apex, but obsolete toward the hinder edge. Hind wings uniformly lemon yellow, duller toward the base of the wing. Legs: femora yellow, tibiae and tarsi pale pink on the outside.

Expanse of fore wings, ♂, 84 mm., length 38 mm., breadth 18 mm. Hind wings, length 25 mm., breadth 19 mm.

In Druce's figure a basal line on the fore wing is represented. The ♀ is the same but larger, with the usual sexual differences; the outer edge of the hind wings is full and convex, while the fore wings are more obtuse. (For the venation see Pl. LVII, figs. 3, 3a.)

*Geographical distribution.*—Vera Cruz, Mexico. “Presidio, Mexico, Oaxaca, Amazonas, Pará.” (Druce.)

**ADELOCEPHALA CADMUS** Herrich-Schaeffer.

(Pl. LXI, fig. 2.)

*Adelocephalia cadmus* HERRICH-SCHAEFFER, Sammaburg Aussereur. Schmett., pp. 60, 78. Fig. ♂, 77, 78. 1854.  
*Othorene cadmus* Boisduval, Annales Soc. Ent. Belge, XV, p. 83. 1872.

*Adelocephalia cadmus* Druce, Biol. Central American Lep. Het., I, p. 171. June, 1886.

KIRBY, Syn. Cat. Lep. Het., I, p. 741. 1892.—DYAR, Proc. Ent. Soc., Wash., IV, p. 427. May 13, 1901.

*Imago.*—1 ♂, closely resembling *A. bisecta* and also *högei* in the shape of the fore wings, but compared with *A. bisecta* the costa is more convex at apex, and the outer edge is more convex, being decidedly so. In the antennæ there are 22 pairs of pectinations, and the filiform tip is composed of about 15 joints, with short toothlike vestigial pectinations on the outside.

Body and wings of a pinkish chestnut brown. Thorax slightly pinkish. Fore wings of a pure chestnut hue, with no flecks, pinkish at base and along the inner edge, including the fringe. Traces of a pinkish basal shade. Extradiscal line faint, oblique, ending on the apex; beyond it the wing is washed with pink, but the fringe on the outer edge is pale chestnut; a minute white roundish discal dot. Hind wings with outer edge full, rounded, though a little angular below the apex and inclined to be very slightly excavated behind the middle of outer edge (this is apparently much exaggerated in Herrich-Schaeffer's figures); no lines or discoloration; a little more pinkish on the inner edge. Under side of the wings chestnut brown; no lines, only a very faint extradiscal brownish shade on both wings, beyond which the wing is paler, with a slight pinkish tinge; costa of hind wings pinkish. Legs pinkish. (For the venation see Pl. LVII, figs. 2, 2a.)

Expanse of the fore wings, ♂, 75 mm. (expanse of ♀ according to H.-Schaeffer's figure 120 mm.); length of one fore wing, ♂, 49 mm.; breadth of one fore wing, ♂, 20 mm.; length of one hind wing, ♂, 26 mm.; breadth of one hind wing, ♂, 19 mm.

*Geographical range.*—Vera Cruz, Mexico, “rare” (Franck); Brazil (H.-Schaeffer); Novo Friburgo, near Rio Janeiro, Brazil (Boisduval). This species is the type of Boisduval's genus *Othorene*.

The Mexican form appears to be the same as the Brazilian Cadmus, only differing from H.-Schaeffer's figures of the ♂ in the absence of a stigma, and in the basal two-thirds of the hind wings not being so distinctly pinkish, while the hind wings are not so angular.

From Boisduval's description it differs in not being “d'un gris rosé.” It may be a permanent climatic variety, and if found to be distinct may be named *castanea*.

He defines the larvae as having the prothoracic segment provided with sharp spines of moderate length; the two following segments with dentate spines and the abdominal segments

bristling with long hooked (*crochets*) spines of equal length and curved backward. He says that he has a larva of *A. cadmus* in alcohol, but, unfortunately, does not specifically describe it.

**ADELOCEPHALA SUBANGULATA (Herrich-Schaeffer).**

(Pl. XIX, fig. 2.)

*Sphingicampa subangulata* HERRICH-SCHAEFFER, Ausscereur. Schmett., I, p. 60, 81, ♂, figs. 304, 305. 1855.  
*Adelocephalia subangulata* BOISDUVAL, Annales Soc. Ent. Belgique, XV, p. 92. 1872.—KIRBY, Syn. Cat. Lep.

Het., I, p. 742. 1892.—PETERS, Die Heteroceren-Raupen, p. 10 (1898), 1901.  
*Syssphinx subangulata* DYAR, Proc. Ent. Soc. Wash., IV, p. 430. May 13, 1901.

*Larva.*

PETERS, Die Heteroceren-Raupen, Taf. III, fig. 4, pupa 4a (1898), 1901.

*Imago.*—♂. In the shape of the body and outlines of the wings allied to *A. bisecta*. The antennae are much as in *A. bisecta*, but the vestigial pectinations of the filiform tip are a little more marked and each end in a fine seta.

Fore wings acute toward the apex; outer edge oblique, not convex, but very slightly excised or hollowed out. Hind wings rounded at the apex and slightly angulated on the inner angle; outer edge less full than in *A. bisecta*. They reach, as in *A. bisecta*, a little more than one-half or two-thirds the length of the abdomen; tip of the abdomen with an irregular terminal tuft.

Body and fore wings tawny or pale brown rather than ocherous. A faint basal and a more distinct linear extradiscal line, which is oblique and slightly incurved, ending on the costa a little before the apex. Beyond this line the edge of the wing is slightly pinkish, and the entire wing is finely dusted with dark scales. A faint, rather large, roundish ring-like discal spot, which appears through from beneath.

Hind wings deep pink, more tawny on the costal, outer and inner edges. No discal spot above.

Under side of the fore wings with a large squarish dark-brown discal spot, and behind it a large part of the wing is deep roseate pink, this hue extending to the distinct extradiscal line, beyond which the wing is frosted over with white scales.

Hind wings beneath of the same color as the outer edge of the fore wings, being hoary or tawny gray. No discal spot visible beneath. On the fore tibiae is a narrow but well-developed epiphysis, which is about one-half as wide in proportion as that of *A. montezumana*, sp.; it is lanceolate oval, nearly three times as long as wide, narrow and pointed at the end. (Pl. XXXVI, fig. 12.)

The maxillæ in this species are well developed compared with the other species we have observed; the two are separate, but curled up, each maxilla nearly as long as the filiform tip of the ♂ antenna. The palpi are small, slender, not easily perceived in the undenuded specimens; they do not reach the front; they ascend and are much compressed.

♀ Larger than the ♂, with the fore wings rounded and the outer margin beyond the discal line brownish; hind wings of a more obscure red; under side of the fore wings whitish, with a common brownish line. Fore wings beneath with a black lunate discal spot, as in the ♂, though the disk is here whitish, not roseate (Boisduval).

Expanse of the fore wings: ♂, 62 mm.; length of one fore wing, ♂, 30 mm.; breadth of one fore wing, ♂, 14 mm.; length of the hind wings, ♂, 20 mm.; breadth of the hind wings, ♂, 18 mm.

*Larva.*—Imperfectly preserved; the spines on second and third thoracic rings are quite long, black, and toothed; the prothoracic collar is also provided with stiff points or tubercles (Boisduval).

PETERS describes the larva as dark green, with a blue head and a lateral streak, the trunk segments beset with silver spines. It lives on a spiny climbing plant.

He also states that the larva of *A. brevis* (Taf. III, fig. 5) is very similar to that of *A. subangulata* and lives on the same plant, yet the imago is very different. He found in Rio the larva of this species on a spiny Mimosa.

Boisduval, referring to a badly preserved specimen, remarks: "Les épines ou pointes sont noires, assez longues et dentelées sur le second et le troisième anneau; la collarète est aussi garnie de pointes roides."

*Geographical distribution.*—Brazil (Donckier, Boisduval, Peters). It is not known from any other country than Brazil. Boisduval states that it is in certain years very common in Brazil, while during others only a few caterpillars occur.

ADELCEOCEPHALA WARDII (Boisduval).

(Pl. XXXIII, fig. 2.)

*Othorene wardii* BOISDUVAL, Annales Soc. Ent. Belgique, XV, 1872, p. 84, Pl. III, fig. 2. 1872.—BURMEISTER,

Deser. Phys. Rép. Argentine, Atlas, p. 46. Larva Pl. XX, fig. 3. 1879.

*Adeloccephala wardii* KIRBY, Syn. Cat. Lep. Het., I, p. 741. 1892.

*Othorene wardii* PETERS, Heteroceren-Raupen, p. 10, Taf. III, fig. 1a, 1. (1898-) 1901.

*Larva.*

(Pl. XVII, fig. 3.)

BURMEISTER, I. c. Atlas, Pl. XX, fig. 3. 1879.

PETERS, Heteroceren-Raupen, p. 10, Taf. III, fig. 1; 1a, pupa. (1898-) 1901.

*Imago.*—1♂, 1♀. In the male the shape of the wings is as in *A. högei* and more especially *A. boisduvalii*, but the costa is still more straight, and the fore wings are more acute at the apex, being a little longer and narrower than in either of the two species named. The hind wings are of the subtriangular shape of those of *A. boisduvalii* and *subangulata*, the apex being well rounded and the outer edge very slightly excavated; the end of the abdomen is broad, flattened, not laterally tufted; antennae broadly pectinated on the basal half.

Thorax and fore wings of a beautiful, soft, hoary, purplish hue; the middle of the thorax ochre yellow, the band widening toward the abdomen, the base of which is also yellowish. Fore wings hoary lilac along the costa and in the middle and on the outer edge of the wing; on the base of the wing behind the costal edge an ochreous patch, and another broad one near the outer edge, ending on the internal angle. No definite transverse lines, but a broad ochreous region or band extends from the two white discal spots to the apex, the apical portion of the costa being ochreous; this ochreous band is mottled with purplish. The two discal spots of unequal size, not as in *A. högei*, arranged in a line at right angles to the costal edge, but parallel with it. Hind wings ochreous at base and on the outer edge, the rest of the wing dull, purplish. Beneath, the wings of both pairs are purplish, marked with ochreous near the apex and along the inner edge. Abdomen purplish, with yellow bands on the basal two-thirds.

In the female the fore wings are broader, less acute at the tip, of much the same shape as in *A. bicolor* ♀; the hind wings are not triangular, but of the normal shape, the apex being rounded and the outer edge full and rounded. Thorax as in the ♂, but the yellow median band narrower. The wings of both pairs uniformly clear, beautiful fawn brown or dark leonine, without strigæ; the fore wings hoary and purplish violet at base, and along the outer edge a single minute discal dot. Hind wings like the fore wings, with no markings.

Expanse of fore wings, ♂, 72 mm.; ♀, 52 mm. Length of fore wing, ♂, 37 mm.; ♀, 27 mm. Breadth of fore wing, ♂, 15 mm.; ♀, 12 mm. Length of hind wing, ♂, 20 mm.; ♀, 15 mm. Breadth of hind wing, ♂, 15 mm.; ♀, 13 mm.

Burmeister states that the female is double the size of the male. It is very different. A female in Strecker's collection is of the same color as *Othorenia sepiularis*.

This is the most conspicuously marked species of the genus, differing from all the others known to me in the beautiful, soft, frosty, purplish-brown tints, the more yellow shades, and in the arrangement of the two oval, discal, white spots.

Peters speaks of the remarkable sexual dimorphism of this species, the male with a ground color of chocolate brown, but with large yellowish patches, as in my male above described.

Though the larva is of the type of *A. bicolor* in the abdominal dorsal spines being alternately long and short, the moths of the two species differ very much in the shape of the wings of the male. Boisduval's figure represents it fairly well.

*Larva* (Plate XVII, fig. 3).—Burmeister speaks of it as being the most remarkable of all the species of "Ceratocampa." The segments of the body are short though large, with deep sutures between them. The first thoracic segment bears four dorsal spines, with two on each side in front of the stigmata. The second and third bear two stout dorsal violet spines and one on each side. Of the abdominal dorsal spines those of the second, fourth, and sixth segments are very large and of a brilliant silver hue, while those of the alternating segments are violet. The long caudal horn is violet. The suranal plate is coarsely granulated.

Peters describes the larva as green with three great shining silvery spots on the side, and with a number of gleaming spines.

*Pupa*.—Of the usual generic form, with a long cremaster and stout, short spines on the head.

*Geographical distribution*.—Rio Janeiro, Brazil (Burmeister; Peters).

*Food plants*.—It lives on various leguminous plants, notably a spiny Mimosa whose leaves are violet brown on the under side (Peters).

#### ADELOCEPHALA ANTHONILIS Herrich-Schaeffer.

*Adelocepha anthonilis* HERRICH-SCHAEFFER, Saml. Aussereur. Schmitt., p. 60, pl. 17, figs. 79. 1854.—WALKER, Cat. Lep. Het. Brit. Mus., VI, p. 1499. 1855.—BOISDUVAL, Annales Soc. Ent., Belgique, XV, p. 88. 1872.—KIRBY, Syn. Cat. Lep. Het., I, p. 741. 1892.

*Syssphina anthonilis* DYAR, Proc. Ent. Soc., Wash., IV, p. 429. May 13, 1901.

*Imago*.—♀ of a peculiar uniform grayish brown, neutral tinted or slate color. An oblique basal dark narrow line; extradiscal line common to both wings; that of the fore wings slightly sinuous and ending on the costa near the apex; that of the hind wings curved outward, a faint discal line. In shape the wings are like the female of *A. senatoria*, and the body and wings are of the same size. We have not seen an example of this species, but judging from Herrich-Schaeffer's figure of it the ♀ resembles an *Anisota* in general appearance, but the larval shape shows that it belongs in the present genus. It presents none of the characters of *Syssphinx*; certainly not those of the larval stage.

*Larva*.—Entirely black and provided with long spines of equal length, all curved backward, like that of a porcupine when walking. The spines of the first thoracic segment (collerette) are very marked, but much shorter than the others (Boisduval).

*Geographical distribution*.—Brazil (Herrich-Schaeffer; British Museum).

*Food plants*.—It lives on several kinds of trees and the moth is disclosed at two epochs (Boisduval).

Judging by Boisduval's statement, this species, whose larva is armed with well-developed prothoracic dorsal spines, must be a primitive form.

#### ADELOCEPHALA JUCUNDA Walker.

*Adelocepha jucunda* WALKER, List Lep. Br. Mus., VI, p. 1500. 1855.—BOISDUVAL, Ann. Soc. Ent. Belgique, XV, p. 91, 1872.—KIRBY, Syn. Cat. Lep. Het., I, p. 742. 1892.

*Adelocepha dimidiata* HERRICH-SCHAEFFER, Aussereurop. Schm. fig. 307. 1855.—KIRBY, I. c., p. 742. 1892.

*Imago*.—♂. Shape of the wings and antennae as in *A. bicolor*, but the hind wings more rounded at the apex and more produced toward the inner angle. It is of a more uniform darker chestnut or fawn color than any of the other species. A shade passes from the base of the fore wings along the cubital vein turning up to the apex; on the costal side, clear chestnut; on the hinder side, lilac and frosted over with white scales. A faint discal dot or streak. Hind wings reddish chestnut. Fore wings reddish beneath, hind wings whitish ocherous, as in the body and legs, though the fore legs are reddish in front. The head in front is white; abdomen whitish on the sides and beneath; fringe of the hind wings whitish ocherous.

Expanse of the fore wings, ♂ 52 mm.; length of one fore wing, ♂ 27 mm.; breadth of one fore wing, ♂ 12 mm.; length of one hind wing, ♂ 18 mm.; breadth of one hind wing, ♂ 13 mm. This is a very peculiar and well-marked species of the size of *A. wardii*.

Herrich-Schaeffer states that his *dimidiata* is a synonym of Walker's species.

*Geographical range*.—Brazil (Neumegen Coll. Brooklyn Museum); (British Museum).

#### ADELOCEPHALA BREVIS Walker.

*Adelocephala brevis* WALKER, Cat. Lep. Het. Br. Mus., VI, p. 1500. 1855.—BOISDUVAL, Annales Soc. Ent. Belge, XV, p. 89. 1872.—PETERS, Die Heteroceren-Raupen, p. 10. (1898)—1901.  
*Syssphinx brevis* DYAR, Proc. Ent. Soc. Washington, IV, p. 429. May 13, 1901.

##### *Larva.*

PETERS, Die Heteroceren-Raupen, Tab. III, fig. 5. (1898)—1901.

*Imago*.—1 ♀. A distinct species allied to *A. bicolor*, but the apex of the fore wing is a little more acute than in ♀ of that species. Ground color uniform light gray, of the hue of a pale, dead leaf with scalloped striga; the shade is peculiar and unlike that of any other species. A distinct dark extradiscal line extending from within the middle of the inner edge of the wing to the costa just before the apex; an obscure oblique basal line.

Hind wings with a single line extending across the middle; no discal spot beneath.

Expanse of fore wings, ♀ 68 mm.; length of one fore wing, ♀ 35 mm.; breadth of one fore wing, ♀ 16 mm.; length of one hind wing, ♀ 21 mm.; breadth of one hind wing, ♀ 15 mm.

*Geographical range*.—Brazil (Neumegen Coll. Brooklyn Museum); Rio de Janeiro. The specimen in the Neumegen collection does not exactly agree with the descriptions of Walker and Boisduval, and further comparisons are necessary.

*Larva*.—Boisduval states that the caterpillar is yellowish green with the spines of a brilliant golden hue, of medium length, curved backward and directed backward; the horns on the second and third thoracic segments toothed, as is also the caudal horn. The first thoracic segment (collerette) has no spines, these being replaced by small conical tubercles.

Peters states that the larva is very similar to that of *A. subangulata* and lives on the same climbing, prickly plant; also on a spiny Mimosa.

#### ADELOCEPHALA CROCATA Boisduval.

*Adelocephala crocata* BOISDUVAL, Annales Soc. Ent. Belgique, XV, p. 90. 1872.—KIRBY, Syn. Cat. Lep. Het., I, p. 741. 1892.

*Adelocephala argyraantha* BOISDUVAL, I. c., XV, p. 90. 1872.—VAR. KIRBY, I. c., p. 741. 1892.

*Syssphinx argyraantha* DYAR, Proc. Ent. Soc. Wash., IV, p. 429. May 13, 1901.

*Imago*.—1 ♂. “One of the smallest species; its fore wings are of a tawny yellow, as also the thorax and abdomen; the fore wings are obliquely crossed from the apex to the middle of the inner margin by a very narrow brown line; a basal sinuous obscure line; a white discal dot; outer edge of the wing bathed with rosy gray; hind wings unspotted, with the fringe paler; wings beneath yellowish, with an oblique brown line; the discal region of the fore wings yellow, with a darker central dot.” (Boisduval.)

In the Neumegen collection of the Museum of the Brooklyn Institute is a male from Brazil. It is a small species. The body and wings are ocherous. It differs from *A. argyraantha* in having on the fore wings a small white discal spot; the extradiscal line fades out before reaching the inner edge, while in *A. argyraantha* it distinctly ends on the inner angle of the wing, curving around to it, and the discal dot is not white, but deep ocherous brown. The fore wings on their under side are ocherous, with a pinkish wash toward the apex, and the body and hind wings are whitish ocherous, almost chalky white.

Expanse of fore wings, ♂ 42 mm.; length of one fore wing, ♂ 21 mm.; breadth of one fore wing, ♂ 9.5 mm.; length of one hind wing, ♂ 15 mm.; breadth of one hind wing, ♂ 11 mm.

*Geographical range*.—Brazil (Boisduval, Neumegen).

Var. *Adelocephala argyraantha* Boisduval, Annales Soc. Ent. Belgique, XV, p. 90. 1872.  
Burmeister, l. c., Pl. XXIII, fig. 7. 1879.

*Larva*.

Pl. XLIX, fig. 1.

Boisduval, Annales Soc. Ent. Belgique, XV, p. 91. 1872.

Burmeister, Atlas de Deser. Phys. Rép. Argentine, p. 52. Pl. XXIII, fig. 7. 1879.

*Imago*.—1 ♂. In this form, regarded by Kirby as a variety of *A. crocata*, and which appears to be so from an examination of the Neumegen collection, both wings and also the body are ochreous, while the fore wings are more pink toward the apex.

Expanse of the fore wings, ♂ 40 mm.: length of one fore wing, ♂ 19 mm.: breadth of one fore wing, ♂ 8 mm.: length of one hind wing, ♂ 13 mm.: breadth of one hind wing, ♂ 9 mm.

*Larva*.—Resembles that of *brevis*. Green or yellowish green, with the spines shining like polished silver, curved backward and pointing backward, of nearly equal length, those of the second and third segments toothed, as also the caudal horn, which looks like a recurved tail. The front edge of the prothoracic segment (collerette) is garnished with quite prominent silvered spines. (Boisduval.)

We copy (Pl. XLIX, fig. 1) from Burmeister his figure of the larva of *A. argyraantha*. He states that the prothoracic spines are reduced to small hemispherical tubercles; the dorsal spines of the two hinder thoracic segments, with the caudal horn, are very large and have the angles toothed before and behind; all the spines are bilateral and distinctly compressed. In the living caterpillar the spines and tubercles are magnificently silvered on the outer side, but roseate on the inner side.

The pupa lies in the earth in a cavity lined with silken threads.

*Food plant*.—In Buenos Ayres the larva feeds on *Gleditschia tricanthos*.

*Geographical range*.—Boisduval states that this and *anthoniensis* are the two species most frequently met with in the vicinity of Novo Friburgo, though the moths themselves are rarely seen.

On the label of the specimen in the Neumegen collection Paraguay is given as the locality. Burmeister records it from Buenos Ayres.

*Adelocephala larva not determined* (Pl. III, fig. 1).—The following description is drawn up from a dry and contracted caterpillar from Brazil, obtained through M. Donckier: It is a form of remarkable interest, since it appears to be more primitive in its characters than any other species yet known. This is seen in the unusual development of the prothoracic spines and in the equality in the size and unusual length of the dorsal spines of abdominal segments 1-7.

Head (Pl. XLIV, fig. 13) conical, much more so and also higher than in *A. sisus*, and still more so than in *A. bicolor*. It is of a rich olive sea green, with a broad whitish band arising from just in front of the ocelli, ending on the vertex, and edged behind with a dark-green parallel line.

Prothoracic segment with high dorsal (*i*) and subdorsal (*ii*) spines, polished, silvery white or porcelainous, erect, nearly smooth, with minute low spinules, and nearly as long as the horns behind are thick. Two dorsal (*i*) and two subdorsal (*ii*) spines or horns on each of the two following thoracic segments, which are about as long as the head is high or as the body is thick, and smooth in front; they are smooth in front, but behind bear, besides a few minute ones, four or five large rounded spinules about twice as long as thick in the middle. The distal third of each horn is smooth. The horns are sharp and decidedly recurved; the subdorsal ones (*ii*) are but slightly shorter than those of the dorsal series; those below (*v+v* and *vii*) are mere short tubercles.

On abdominal segments 1 to 7 the dorsal spines (*i*) are saber-shaped, compressed, recurved, and very long, but little shorter than the subdorsal horns and about two-thirds as long as the caudal horn. They are polished, glistening, and in life were probably porcelain or silvery white. All of the series are of the same length and but little shorter than the subdorsal horns (*ii*) and

about two-thirds as long as the caudal horn. Those of the subdorsal series ( $\text{vii}$ ) are at base broader in proportion than the dorsal ones and very sharp. Those of the infraspiracular series ( $\text{v} + \text{v}$ ) are well developed, sharp, though but one-half as long as those of the subdorsal series. Caudal horn large (fig. 4e), unevenly though decidedly forked at the end and bearing rounded knobs or tubercles, some of which are quite long and slender. The horn is a little longer than the thoracic dorsal horns and nearly three times as stout.

On the ninth abdominal segment is a median tubercle about twice as large as those next to it. It is polished and silvery.

Suranal plate (Pl. LIV, fig. 7), triangular, not rounded as usual, thick and solid, especially on the edges, with rounded knoblike reddish tubercles, four on each side, and more numerous smaller ones on the under side of the edge. Across the base is a row of four small tubercles, succeeded by a parallel row of smaller tubercles. The end of the plate is forked, each division formed by a large stout tubercle.

Anal legs with cream-white porcellanous granulations or bosses around the thickened edges, while the center is smooth. Spiracles green. The trunk segments are all smooth, without the granulations present in *A. bicolor* and the San Antonio larva. Length about 40 mm.

This larva is of remarkable interest, since there are quite high spines on the prothoracic segment, showing that this species is the most ancestral and primitive, nearer the stem form than any other species of the genus whose larva is known. I had thought that *Ctheronia regalis*, with its long prothoracic spine, might be the stem form of the group, though the pupa is by no means so primitive as that of the other genera. This South American larva, however, is apparently the most ancestral of any of the Ceratocampinae yet known, and indicates that eastern South America was the center of origin of the family. It appears to be allied to the larva of *A. brevis*, as figured by Peters (Pl. III, fig. 5), in which there appears to be, judging by the poor figure, short prothoracic spines, while the dorsal spine of the abdominal segments is represented as being as long as the thoracic horns. Whether the undetermined Adelocephala figured by Peters (Pl. III, fig. 6), with very long, slender horns on all the segments, is a true Adelocephala seems uncertain.

The following species from Central and South America have not been examined by me:

- Adelocephala jason* Boisduval, l. c., p. 83. 1872. Mexico.
- Adelocephala fallax* Boisduval, l. c., p. 84. Pl. III, fig. 3. 1872. Mexico.
- Adelocephala leucantha* Boisduval, l. c., p. 89. 1872. Brazil.
- Adelocephala erubescens* Boisduval, l. c., p. 91. 1872. Brazil.
- Adelocephala flaviguttata* Walk., Cat. Lep. Het. Br. Mus., XXXII, p. 575. 1865.
- Adelocephala tristigma* Boisduval, l. c., p. 86. Pl. III, fig. 4. 1872. Brazil.
- Adelocephala leucostigma* Boisduval, l. c., p. 85. 1872. Guatemala; Oaxaca, Mexico.
- Othorene arpi* Schaus, Amer. Lepidoptera, I, p. 20, Tab. III, fig. 7. 1892. Rio Janeiro.
- Othorene janira* Schaus, I, c., p. 20, Tab. III, fig. 9. 1892. Rio Janeiro.
- Othorene inralida* Schaus, I, c., p. 20. Tab. III, fig. 8. 1892. Rio Janeiro.
- Othorene columbiensis* Schaus, I, c., p. 21. Tab. III, fig. 13. 1892. Colombia.
- Adelocephala acuta* Schaus, Journ. N. Y. Ent. Soc., IV, p. 59. Aroa, Venezuela.

#### CRINODES BELLATRIX Stoll.

*Bombyx bellatrix* Stoll, Papillons exotiques, IV, taf. 305 F. 1781? Suppl. Taf. XXII, p. 106, fig. 3. Larva. 1791.

*Crinodes bellatrix* Herrich-Schaeffer, Aussereurop. Schmett., I, p. 11. 1855.

*Astylis bellatrix* Boisduval, Annales Soc. Ent. Belgique, XV, p. 94. 1872.

*Crinodes bellatrix* Kirby, Syn. Cat. Lep. Het., I, p. 616. 1892.

In the absence of any material for examination I can only follow Boisduval in regarding this moth as belonging to this subfamily. The moth, judging from Stoll's figure, differs from Adelocephala. The species figured by him is apparently a female, with filiform antennae, but Boisduval states that those of the male are finely pectinated on the basal two-thirds. It does not appear to belong with the Notodontidae, where it was placed by Herrich-Schaeffer and by Kirby.

The larva, judging by Stoll's figure, appears to be allied to that of Adelocephala. The head

is large, the prothoracic dorsal horns are longer than thick, showing the primitive nature of the genus. The caudal horn is not clearly shown; the lateral infraspiracular spines are a little longer than in *A. argyraeaanthia*. Though the figure is poorly drawn, the suranal plate and anal legs appear to resemble those of Adelocephala.

The pupa is undoubtedly closely similar to that of Adelocephala, the cremaster being long, slender, and deeply forked.

The larvae of Boisduval's Astylis, which includes *A. boshii* and *A. sommeri*, both from Brazil, live on different species of bananas (*Musa sapientum*, etc.).

*Geographical distribution*.—Surinam to Brazil (Stoll, Boisduval).

Until examples of the moths and larvae can be had for study it is impracticable to further discuss the species of this genus.

*Crino sommeri* Hübner will probably be found to differ generically from *C. bellatrix*; in fact it does not appear to belong with the Ceratocampinae, and may prove to be a noctuid.

#### SYSSPHINX Hübner.

(Pls. XXXIII, fig. 4; LVII, figs. 4, 4a-4c.)

*Syssphinx* HÜBNER, Verzeichniss Schm., p. 143. 1818-1822.

*Syssphinx* WALKER, Cat. Lep. Het. Br. Mus., VI, p. 1503. 1855.

*Psephopactes* GROTE, Trans. Amer. Ent. Soc., I, p. 5. June, 1867. ♂.

*Adelocephala* GROTE, Trans. Amer. Ent. Soc., I, p. 7. June, 1867. ♀.

*Ceroderes* BOISDUVAL, Annales Soc. Ent. Belgique, XV, p. 81. 1872.

*Syssiphine* BURMEISTER, Deser. Phys. Rép. Argentine, V, Lép., Pt. 1, p. 492. 1878; Atlas, p. 45. 1879.

*Syssiphine* DRUCE, Biología Centr.-Amer. Insecta, Lep. Het., I, p. 172. June, 1886.

*Syssiphine* KIRBY, Syn. Cat. Lep. Het., I, p. 741. 1892. Schaus, Amer. Lep., p. 19. 1892.

*Imago*.—♂ and ♀. Head much depressed, triangular in front, wide between the antennae, but rapidly narrowing much more than in Adelocephala toward the labrum; the end of the clypeus is prolonged into a large solid knob-like protuberance. In this respect the genus differs from any other of the subfamily. Eyes rather large, larger than in Anisota. Palpi minute, short, slender. Maxillae of male well developed, more so than usual, being longer than in Adelocephala. The two are separate, loosely curled up, and would, if extended, reach well beyond the front; those of the female invisible. Antennae of ♂ widely bipectinated to a little beyond the middle, beyond filiform, without distinct teeth, but instead a pair of rather long fine setae. Those of ♀ perfectly filiform, with no denticles or setae, being simple and round.

Thorax full, the front overhanging the head as in Adelocephala. Fore wings Smerinthus-like, with the costa straight, the apex sharp, in ♂ the oblique outer edge distinctly, in ♀ slightly scalloped and convex.

Hind wings of ♂ rounded at the apex; outer edge excavated; inner angle well rounded, but in ♀ rounded as usual, and the outer edge not excavated but full, more as in Adelocephala and Anisota. Hind wings in ♂ reaching to the outer fourth of the abdomen; in ♀ to the end of the latter, extending farther in this direction than in Adelocephala and Anisota.

Venation (Pl. LVII, figs. 4, 4a, 4c): As in Eacles, Anisota, and Adelocephala vein III, is wanting; the venation differs in no important respects from Anisota and Adelocephala, as will be seen by reference to the figures. The two discal veins make a decided angle, as also seen in *A. heiligbrodtii*. In the hind wings the discal veins are less oblique, the two taken together making more of a curve than in Anisota and Adelocephala.

Coloration: In general ochre yellow; the hind wings are pink in the middle; no discal spot on the fore wings above, but beneath is a large black discal patch. The two usual lines, basal and extradiscal, well marked. On the hind wings a large black roundish discal spot, not centered with white; this spot is not repeated beneath; the extradiscal line is present, though not very distinct.

Genitalia (Pl. XLI, figs. 2, 2d): The suranal plate a flat oblong plate of uniform width, ending in a fork (as in certain Sphingidae). A single pair of claspers, which are quite wide,

ending in two points, the inner much larger, forming a long sharp spine. Penis a thick cylindrical style, obtuse at the end. The armature differs decidedly from that of *Anisota* and *Adelocephala* in the simple flat suranal plate, the 2-spined claspers, and the thick obtuse penis.

This genus, as already remarked by Grote, "bears a remarkably close though superficial resemblance to *Smerinthus*, and Boisduval afterwards stated that it has a slight resemblance to certain varieties of *Smerinthus pupillata* in the shape of the fore wings, with their scalloped outer edge." Also the tongue is unusually well developed, though Grote states that the oral structure is obsolete. This might by some be regarded as a case of mimicry, though the genus probably lived long anterior to a modern specialized sphingid. It differs from *Adelocephala* in its larval characters, there being no dorsal spines on abdominal segments 1 to 7, as well as in the genital armature; hence there seems no cause for uniting any of that genus with it.

There is a good deal of discrepancy (Androrophy) between the two sexes, so much so that the female was referred by Grote to *Adelocephala*, and the male to his genus *Psephopaeetes*, this being a remarkable case of male divergence from the more normal or primitive type, which has been preserved by the female.

The head in front is much narrower than in *Adelocephala*, and the clypeus is remarkably produced into a prominent knob-like projection, which, so far as I know, is unique in the moths.

*Larva*.—*Stage I*.—Very similar to *A. bicolor*, but body not striped; prothoracic segment unarmed; eight long thoracic horns like those of *A. bicolor*, other spines as in *bicolor*, but slightly more developed; caudal horn larger and higher, ending in a thick swollen knob, which is square seen from in front, with a bristle on each side.

*Last stage*.—Body thick; it differs from *Adelocephala* in the thoracic spines being stout and very short, while there are no spines on the first to seventh abdominal segments; the caudal horn is very short, not much higher than thick. The third thoracic and eighth abdominal segments are swollen.

*Geographical distribution*.—This genus ranges from the tropical zone or eastern coast of Mexico (Jalapa) to Brazil, extending southward, according to Peters (in Schröder), to the La Plata, and presumably northeastern Argentina.

*Flood plant*.—“*Juga vera*.”

*History of the genus*.—The group is monotypic, there being but a single species, *S. molina*, mentioned by Hübner, who placed it between the Sphinges and Endromis, quite remotely from Eacles and Citheronia, the gap between being filled by the Notodontidae, Drepanulidae, certain Saturniidae, and Aglia and Dirphia.

#### SYSSPHINX MOLINA (Stoll).

Pl. XXXIII, fig. 4.

*Phatnia-Bombyx molina* Stoll. Papillons Exott., IV, p. 25, 221, Tab. 302, E. F. (♀); Tab. 396, B. (♂). (1781?)  
1782.

*Phatnia molina* Sepp. Papillons de Surinam, III, p. 259, Pl. 118, ♂ and ♀ (Amsterdam, n. d.).  
*Syssphinx molina* Hübner. Verzeichniss Schnett., p. 143. 1818-1822.

*Syssphinx molina* WALKER. Cat. Lep. Het. Brit. Mus., VI, p. 1503, No. 1. 1855.

*Psephopaeetes simulatilis* GROTE. Trans. Amer. Ent. Soc., I, p. 6, Pl. 1, fig. 1. ♂. 1867.

*Adelocephala grandis* GROTE. Trans. Amer. Ent. Soc., I, p. 8, Pl. 1, fig. 7. ♀. 1867.

*Ceroderes molina* BOISDUVAL. Annales Soc. Ent. Belgique, XV, p. 81. 1872.

*Ceratocampa molina* BURMEISTER. Deser. phys. Rép. Argentine, V. Lép., Pt. I, p. 492, 1878; Atlas, p. 45, Pl. xix, fig. 1. 1879.

*Syssphinx molina* DRUCE. Biología Centr. Amer. Lep. Het., I, p. 172. June, 1866.

*Syssphinx molina* KIRBY. Syn. Cat. Lep. Het., I, p. 741. 1892.

*Syssphinx molina* DYAR. Proc. Ent. Soc., Washington, VIII, p. 428. May 13, 1901.

\*See male preponderance (androrophy) in lepidopterous insects, by A. S. Packard. Science, XVII, p. 250, Feb. 13, 1903.



FIG. 10.—Head, denuded, of *Syssphinx molina*; *mx.* vestigial maxillæ, male.

*Larva.*

Pl. III, figs. 4, 4a; XVI, fig. 4; XLVII, figs. 1, 1a-1c.

*Stoll*, Supplement Cramer, Papillons Exot., Pl. 22, fig. 4. 1782.

*Sepp*, Papillons de Surinam, III, Pl. 118, larva and pupa.

Not *Boisduval*, Annales Soc. Ent. Belgique, XV, p. 81. 1872.

*Burmeister*, La description physique de la République Argentine, Lép., atlas, Pl. xix, fig. 4. 1879.

*Peters*, Die Heterocerren-Raupen (Schröder), p. 10, Taf. iii, fig. 2, 2a. 1901.

*Imago*.—2 ♂, 2 ♀. Body and wings pale fawn color or brownish ocherous. Abdomen of the same hue as the head and thorax above and below. Legs darker, becoming purplish on the outside of the tibiae and tarsi.

Fore wings fawn color within and a little darker beyond the extradiscal line. Basal line obscure, a little irregular, oblique, slightly curved outward behind the costal edge. Extradiscal line light brown, oblique, not sinuous in ♂, very slightly sinuous in ♀. Apex of ♂ very acute, below the apex the edge is excavated, leaving a projection in the middle of the wing, while between this and the inner angle of the wing is a rather deep hollow subdivided into two sinuses; in ♀ outer edge moderately convex, not scalloped. In ♂ the outer margin beyond the extradiscal line is somewhat darker than the rest of the wing, and with scattered obscure dusky strigæ, while along the middle of the wing is a hoary purplish or lilac discoloration, which in ♀ is wanting.

Hind wings of the same hue as the anterior pair, but reddish pink in the middle of the wing extending from near the base of the wing to the extradiscal line, but not reaching the costal or inner edge, which is pale ocherous, and of the same hue as the outer edge of the wing beyond the extradiscal line. A large black discal spot, a little larger and rounder in ♀ than in ♂. The extradiscal line is definite and a little curved in ♂, in ♀ much wider and more diffuse, and merging into the pink area. Beneath, the fore wings are stained deep roseate in the middle, including the large discal spot; extradiscal line pink behind, becoming wider, more diffuse, and tawny ocherous toward and on the costa.

Hind wings beneath with no pink and no lines, the extradiscal being obsolete or quite faint, and when visible broad and diffuse. In the ♂ the abdomen is slightly ringed with dark ocherous. The genital armature is as represented on Pl. lxx, figs. 3, 3a; as there is no other species of the genus known, the specific characters can not be drawn up with precision.

Expanse of fore wings, ♂ 90 mm.; ♀ 120 mm. Length of a fore wing, ♂ 40 mm.; ♀ 55 mm. Breadth of a fore wing, ♂ 20 mm.; ♀ 25 mm. Length of hind wing, ♂ 24 mm.; ♀ 34 mm. Breadth of hind wing, ♂ 19 mm.; ♀ 25 mm.

*Geographical distribution*.—Jalapa, Mexico (O. T. Barrett); Mexico (H. Edwards). The following localities are given by Druce: Costa Rica (Van Patten, Gabb, Mus., Druce); Panama, Volcan de Chiriqui (Areco in Mus., Druce); Colon (Boucard, Mus., Druce); Guiana, Surinam, Brazil, Trinidad, West Indies. He adds that the examples from Costa Rica are the darkest and agree fairly well with Cramer's figure. The specimens from Panama agree well with those described by Grote and Robinson, which Mr. Edwards apparently received from the eastern coast of Mexico. It is recorded from South America by Sepp and by Stoll; from the Brazilian coast at Rio by Burmeister. Peters states that it is tolerably common at Novo Friburgo, a town 30 miles northwest of Rio de Janeiro, and he adds that its southern range extends to La Plata.

*Habits*.—Regarding the breeding habits of this interesting moth Mr. Otis W. Barrett writes, under date of May 12, 1900, "Eggs of *Syssphinx molina* are hatching to-day" (twelve days incubation); "oddest looking fellows imaginable."

*Egg*.—It is very large compared with that of *Anisota*, being 2 mm. in length and 1.8-1.9 mm. in width. It is closely similar in shape and nearly as large as those of *Eacles imperialis* and *C. regalis*, being flattened, oval, elliptical. The surface with obscurely hexagonal areas, and from a central boss arises a slender, fine hair, which projects into the interior of the egg, precisely as described under *Eacles imperialis*.

*Larva*.—Stage I.—Length 3.5 mm. (Freshly hatched, but described from five alcoholic specimens, Pl. XLVII, fig. 1, 1a-1c.) Body stouter than in *A. bicolor*, and the head a little larger in proportion. The head is pale sienna brown or yellow ochre. As in *A. bicolor* it is, before the larva has taken food, much wider than the body, and is slightly wider than the prothoracic segment, which is broad and flaring in front as in *Anisota* and *A. bicolor*. It is unarmed as in *A. bicolor*, the front edge of the tergum being coarsely granulated. Of the 8 long horns, 4 on the second thoracic and 4 on the third, the dorsal or inner ones as usual are longer than those of the subdorsal row by the length of the bulb. They are as long as the body from the front of the head to the eighth abdominal median horn, not being quite as long as the

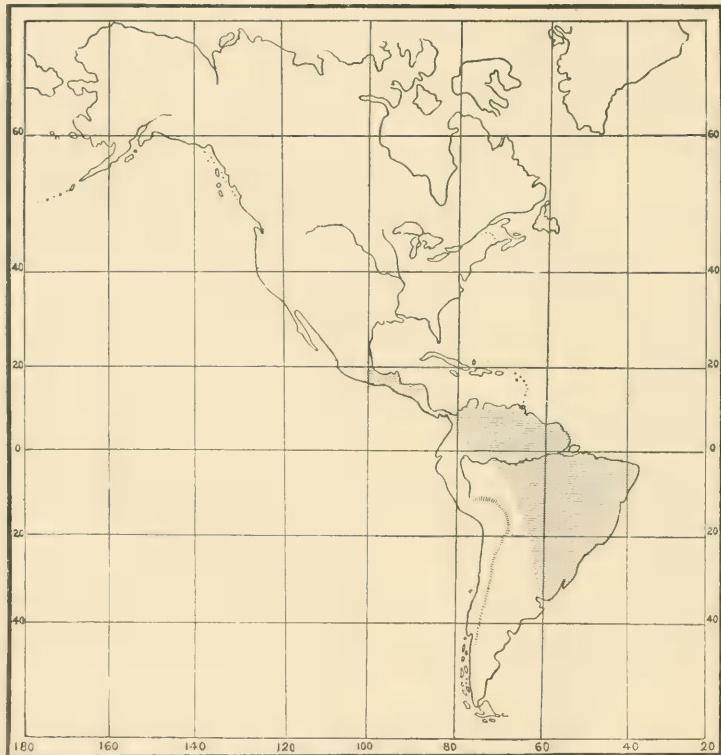


FIG. 11.—Distribution of *Syssphinx molina*.

body itself. They are as usual finely wrinkled. Along the basal half of the stalk are about eight digitiform tubercles, not so many as in *A. bicolor*, and on the distal half only one or two. The bulbous tips are of the same shape and proportions as in *A. bicolor*, being chestnut-like, and the two terminal lateral spines are as in *A. bicolor*, but darker. The dorsal spines on the abdominal segments are as in *A. bicolor*, but differ in being simple, not bearing a minute blunt spine on the base behind. There are no small, setiferous tubercles behind the main or anterior ones, such as occur in *A. bicolor*. The spined tubercles of the infraspiracular row are much longer and deeply forked or double (see fig. 1). On the whole the armature of the body is in this stage more developed than in *A. bicolor*, though undergoing a decided reduction at the end of larval life.

The caudal horn (on the eighth abdominal segment), unlike *A. bicolor*, is larger and higher, as long as the body is thick, ending in a broad, squarish, thick, swollen knob, and is not deeply bifid as it is in *A. bicolor* (figs. 1, *a*, *b*, *1b*). From the anterior edge arise, each from a small tubercle, long bristles, equaling the width of the bulb or knob; the stem bears stouter but a less number of digitiform tubercles than *A. bicolor*.

On the ninth abdominal segment is a minute dorso-median, slender tubercle, giving rise to two slender bristles (*1b*, *ix*); it is much as in *A. bicolor*, but slightly larger and not so dark. All the tubercles on the body, except those on the suranal plate, are finely wrinkled, and the setae are finely but sparsely setose. The suranal plate not granulated; with a large 3-headed tubercle at the base on each side (this is small and simple in *A. bicolor*), three smaller setiferous tubercles on each side toward the end. The general shape and armature of the two forms (*Syssphinx* and *A. bicolor*) is the same as regards the suranal plate and anal legs.

*Syssphinx* on hatching differs decidedly from *A. bicolor* in having no lines, stripes, or any other specialized deposits of pigment, while in alcoholic specimens of *A. bicolor* the dark lines are distinct. Judging from the lack of ornamentation at this stage *A. bicolor* is hatched in a more advanced stage, but judging from the armature (caudal horn) it is decidedly more primitive, this horn reaching a considerable degree of specialization.

*Last stage*.—For a description and colored figure of the fully grown caterpillar we are indebted to Burmeister. He states that it differs from other species of Ceratocampa by the want of spines on the first thoracic and all the abdominal segments except the eighth, which like those on the second and third thoracic segments is "recourbée en crochet." The body is quite thick, the surface of the segments finely granulated with black dots. The ground color is green, with a yellow lateral line, which begins between the dorsal spines of the third thoracic segment. These spines are equally yellow, like the caudal one, all having the tip red.

The eighth abdominal segment is swollen or humped up; the ninth segment and suranal plate are transversely ridged in an unusual way. On each side of the head is a yellow line.

It chiefly differs in the reduction of the thoracic and caudal spines; these being stout and short; those on the two last thoracic segments being conical and not over three times as long as thick at the base, while the caudal horn, judging by Burmeister's figure, is but little longer than thick at the base.

*Pupa*.—Judging from Sepp's figure the pupa closely resembles that of *Adelocephala* and *Anisota*, the cremaster being forked, flat, long, and the body more or less spined.

*Food plant*.—According to Sepp, as quoted by Burmeister, the caterpillar feeds on the "*Jugl vera*." Peters states that "the green, often bluish, caterpillar lives on different Leguminosæ, i. e., on the yellow flowering Cassia and on trees called there (Nova Friburgo, 30 miles from Rio de Janeiro) Sanandú and Bandarra."

#### ?SYSSPHINX PETERSII Peters.

?*Syssphinx petersii* PETERS, Die Heteroceren-Raupen, p. 10, 1901, Taf. III, fig. 3. Pupa, fig. 3a.

*Imago*.—♀ Fore wings reddish brown, with many small black flecks and an oblique transverse externally pale, within darker, line extending from the apex of the fore wing to the middle of the inner edge. Hind wings dark carmine red, with the edges of the color of the fore wings. Abdomen concolorous with the hind wings. Expanse of wings 14–16 cm. (Peters.)

*Larva*.—As figured by Peters it differs from *S. molinae*; there are two twin conical tubercles on the prothoracic segment; a pair of long dorsal spines on the second and third thoracic segments, of nearly equal length, nearly as long as the segments are thick; the body gradually widens to the eighth abdominal segment, which, however, bears no distinct "caudal horn." The larva also differs from that of *S. molinae* in having low conical dorsal tubercles on abdominal segments 1–7. The suranal plate is much longer and larger, though with no salient spines, but marked with yellow warts.

*Pupa*.—Much like that of *Anisota* and *Adelocephala*; the caudal spine being long and slender and slightly forked at the end.

*Food plant*.—It feeds on a high forest Mimosa.

*Geographical range*.—Nova Friburgo, near Rio de Janeiro.

#### ANISOTA Hübner.

(Plates XX.)

*Anisota* HÜBNER, Verzeichniß Schmett. p. 192. 1818-1822.<sup>a</sup>

*Dryocampa* HARRIS, Cat. Ins. Mass. in Hitchcock's Report on the Geology of Mass. 4<sup>th</sup>, 1834, and 2d edit., p. 72 (p. 592), 1835; Treatise Inj. Insects, p. 293, 1841. 3d edit. 1862.—WALKER, Cat. Lep. Het. Br. Mus. VI, p. 1495, 1855.

*Anisota* GROTE, Proc. Ent. Soc. Phil., III, p. 93. June, 1864.

*Dryocampa* and *Anisota* PACKARD, Proc. Ent. Soc. Phil., III, p. 384. Nov., 1864.

*Adelocephala* BOISDUVAL (in part), Annales Soc. Ent. Belgique, XV, p. 88. 1872.

*Anisota* DYAR, List N. Amer. Lep., p. 75. 1902.

*Imago*.—♂ and ♀. Head just visible from above, not entirely concealed by the prothorax as in *Syssphinx*. Front rather wide, not narrowing in front of the labrum, thus becoming triangular as in *Adelocephala hisceta* and in *Syssphinx*; when denuded seems to be flat, somewhat triangular (*A. rubricunda*, Pl. XXXVI, fig. 3), or decidedly so in *A. virginianensis* (fig. 2); the labral end of front  $\frac{1}{2}$ — $\frac{1}{3}$  as wide as between the antennae, while the surface is full and convex. Antennae of ♂ bipectinated to a little beyond the middle; 15 pairs of pectinations, the basal pectinations about as long as the proximal ones; the joints (12 in number) of the filiform end very short, simple; the vestiges of the teeth very short and minute, and giving rise to thin tufts of several fine setae. In ♀ they are filiform and simple. Palpi scarcely visible, so short and feeble; but denuded found to be 3-jointed, joints 1-2 of nearly the same length, third joint about two-thirds as long as second. Maxillæ either entirely wanting or minute, vestigial, not visible. I can not discover in *A. rubricunda* and *virginianensis* any vestiges of them.

Fore wings of ♂ short, narrow, subtriangular to triangular (especially in *A. virginianensis*); costa curved toward the obtuse or subacute apex; outer edge nearly equal in length to the inner, oblique, and either moderately full or straight.

Hind wings short and broad, the outer edge convex, or (in *A. virginianensis*) straight and triangular, with the costa very convex toward the base. The wings reach to the last third or fourth, or near the end of the abdomen. Legs moderately short; the fore tibial epiphysis leaf-like, a little over half to two-thirds as long as tibia; no spurs.

Venation (Pl. XXXIX): as in Eacles, no vein  $III_1$ ;  $III_1$  originates about halfway between the origin of anterior discal vein and that of  $IV_1$ , i.e., beyond the discal cell, while in Citheronia and Eacles,  $III_1$  arises inside of the origin of the discal vein (Pl. LVIII, fig. 5, and p. 56). *A. dissimilis* differs in vein  $III_1$  arising a little within the origin of the discal vein, as in Eacles (Pl. LVII, fig. 5) the discal veins together forming a regular curved line, those of the hind wings oblique. Other less important differences in the venation are brought out by the figures of the different species on Plate XXXIX.

Coloration: The United States forms ocherous, bathed with lilac, or in the Mexican *A. dissimilis* with purplish brown fore wings, and blackish hind wings; fore wings with a distinct discal white spot, which is obsolete on the under side.

Genitalia (Pl. XL): Compared with those of *Adelocephala* to which they are in some respects (suranal plate) nearest allied, the suranal plate is much broader, and ends in two thick rounded lobe-like processes; the chitinous end incurved; tip bidentate; the claspers not so wide as in *Syssphinx*, but much shorter and stouter than in *Adelocephala*, and nearer those of *Syssphinx*, tip ending in two unequal projections. The harpes (*h*) are often well developed, as in *Citheronia*.

<sup>a</sup>Seudder has shown that by the end of 1822 only the first twenty signatures of Hübner's Verzeichniß were printed, the first two signatures only having been printed in 1816, the date on the title-page. Proc. Am. Acad. Arts and Sci., X, 1875, p. 96.

(Pl. LX, figs. 2, 2a, 3b, etc.). Penis complicated; consisting of the slender style-like penis proper, forked at the end, and a wider broad triangular accessory or guard-plate (Pl. XL, fig. 3c,  $I''$ ) situated above it. In the four North American species there seems but little difference in the different parts of the genital armature, and these can be best brought out by reference to my camera drawings in Plates LIX, XLI.

*Egg*.—Elliptical, flattened, each end alike, a little longer than broad; shell very thin, parchment-like, the surface with obscurely marked microscopic irregular hexagonal areas. The eggs are laid in large patches on leaves.

*Larva*.—Body cylindrical, slightly flattened at the end; armature consisting of two recurved slender smooth mesothoracic horns; prothoracic spines reduced to low tubercles; all the other

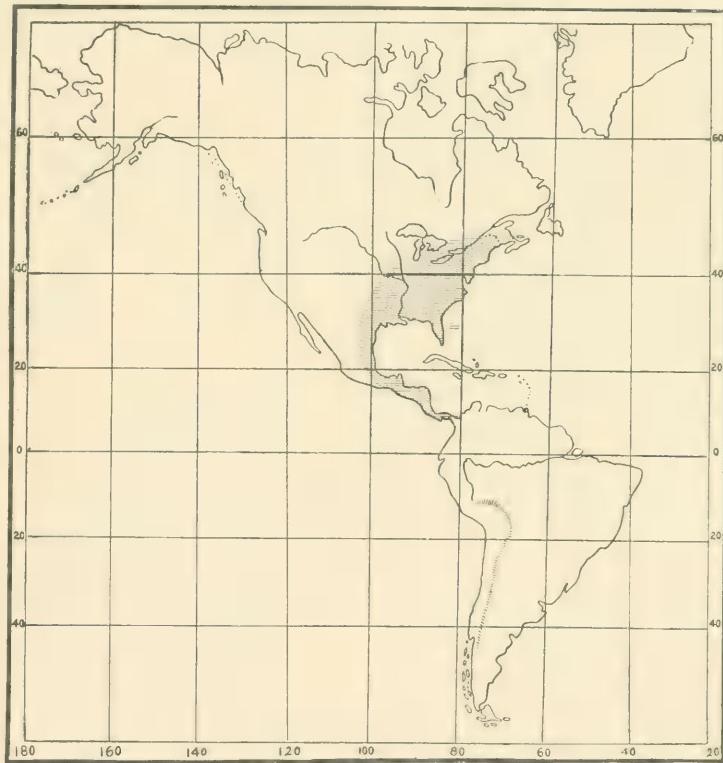


Fig. 12.—Distribution of the genus *Anisota*.

dorsal and lateral spines of the body small, conical, acute; the two dorsal spines of the eighth abdominal segment separate, remote, not fused into a median or caudal horn, but the two tubercles  $i\ i$  on the ninth segment fused into a caudal horn. Suranal plate rugose or granulated, with from three to four lateral and two terminal stout conical spines. Body with conspicuous longitudinal bands or stripes.

*Young larva, stage I*.—Body not spiny with the exception of a pair of smooth horns a little longer than the body is thick, slightly divided at the end, each division bearing a long seta. The other spines represented by minute setiferous tubercles; tubercles  $i\ i$  being present. Suranal

plate rounded at the end. The median dorsal tubercles // on the ninth segment in process of fusion: the two tubercles are separate, though arising from a common base, but minute and each bearing a seta.

*Pupa*.—Body moderately stout; the head overhanging the mouth-region and base of the antenna; the maxilla taken together forming a nearly equilateral triangle, being very much shorter than in Eacles and Citheronia; cremaster long, deeply forked; surface spinose; two rows of spines on the abdominal segments, the sutures between which are deep and wide; the surface less rugose than in Adeloccephala. There seem to be no generic characters, in the pupa, to separate this genus from Adeloccephala, either in the shape of the body, the maxilla, the cremaster, or the armature in general. See also description of the pupa of Eacles.

*Geographical distribution*.—The majority of the species inhabit the United States and Canada east of the one hundredth degree of longitude; 2 occur in Mexico. It is doubtful whether the genus occurs in South America. (Fig. 12.)

*Synonymical history of the genus*.—Under *Anisota* Huebner mentions *A. pellucida*, *stigma*, and *senatoria*. He assigns the genus to a position far removed from the others of its group, between *Malacosoma* (*Clisiocampa*) and *Streblota*. *Dryocampa* is an exact synonym.

*Phylogeny*.—Judging by the stripes alone *A. senatoria* should, perhaps, be regarded as the more primitive form. In this species the dark stripes or lines are developed in stage III, and persist to the end of larval life, where they become the most characteristic style of marking. In *A. rubricunda*, on the contrary, the lines become wholly or partially obsolete in the last stage. In *A. stigma* the dark lines in stage II are very marked, but they are partially discarded in stage III. In *A. virginiana* they are already partly blended in stage II.

It is evident, however, that the armature is preferably to be depended on to give us a clew to the phylogeny of the genus, which has evidently diverged from *Adelocampa*, with its complement of large spines along the entire body. *A. stigma*, with its longer spines, may be regarded as the most primitive species of the genus.

The following diagram will serve to express the relationship as well as the phylogeny of the species of *Anisota*.

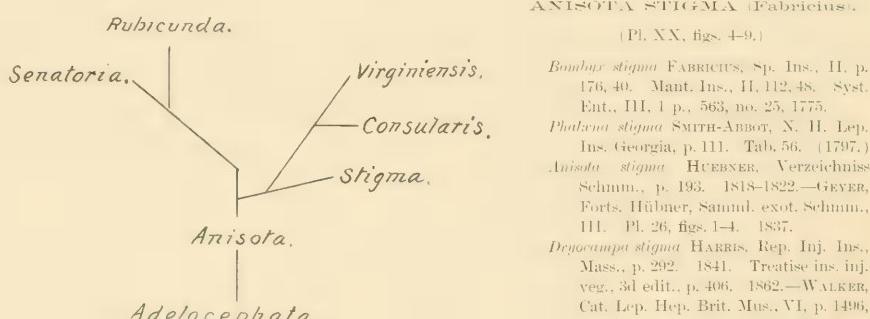


Fig. 13. Affinities and phylogeny of the species of *Anisota*.

- Anisota stigma* GROTE, Proc. Ent. Soc. Phil., III, p. 93. June, 1864.—PACKARD, Proc. Ent. Soc. Phil., III, p. 385. Nov., 1864.  
*Adelocephala stigma* BOISDUVAL, Annales Soc. Ent. Belgique, XV, p. 86. 1872.  
*Anisota stigma* PACKARD, 5th Rep. U. S. Ent. Comm., insects inj. forest trees, p. 125. 1890.—KIRBY, Syn. Cat. Lep. Het., I, p. 739. 1892.—NEUMOGEN and DYER, Journ. N. York Ent. Soc., II, p. 147. Dec., 1894.—BEUTENMÜLLER, Cat. bombycine moths, N. York, p. 439. Pl. xx, fig. 4 ♂. 1898.

*Larva.*

(Pl. V, figs. 1-5; XXX, XXXI, fig. 1; L, figs. 2-2d; LI, figs. 2-2c; LII, figs. 3-3e.)

*Smith-Abbot*, Nat. Hist. Lep. Ins., Georgia, p. 111. Tab. 56. 1797.*Lintner*, J. A., 23d Rep. N. Y. State Cabinet, p. 190. 1873.*Riley*, C. V., in Packard's Rep. U. S. Ent. Commission, insects inj. to forest trees, p. 126. 1890.*Packard*, A. S., Proc. Amer. Phil. Soc., p. 146. March 17, 1893.*Beutenmüller*, W., Cat. bombycine moths, N. York, p. 439. 1898.*Morlatt*, C. L., Trans. Kansas Acad. Sc., 1887-88; XI, p. 111. Figs. 1889.

*Imago*.—4♂ and 5♀. Head, front, and antennae as in *A. senatoria* and *A. virginicensis*, there being no marked differences; tip of antennae filiform, with long fine setæ on each side.

Fore wings of ♂ triangular, rather broad, costa much curved toward the obtuse apex; outer edge nearly straight, a little convex, slightly longer than the inner edge. Hind wings of the normal shape, though short; apex much rounded, and outer edge full and convex, not triangular, and inner angle not partly produced. They reach nearer than in the other species to the end of the abdomen; in ♀ they are much larger. Fore wings of ♀ more produced toward the apex and reaching to the outer fourth of the abdomen.

Body and wings dark reddish ochre, fore wings opaque in the middle, the base of the wings and the outer edge beyond the extradiscal line tinged with lilac. Basal line obsolete. Extradiscal line dark, in some examples slightly sinuous. Discal spot white, round or subtriangular, conspicuous. Wings speckled with scattered dusky strigæ which are rather heavy and distinct, especially on the fore wings and outer edge of the hind wings. The latter of the same hue as the anterior pair; the extradiscal line varies in distinctness. Under side more ochreous, the common extradiscal line distinct and varying in width, being in some very broad and diffuse; the outer edge of the wing lilac and contrasting more than above with the inner ochreous region and more heavily strigated than above.

Expanse of fore wing ♂ 47 mm.; ♀ 53-60 mm. Length of a fore wing ♂ 23 mm.; ♀ 30-34 mm. Breadth of a fore wing ♂ 11 mm.; ♀ 15-17 mm. Hind wings, length ♂ 16 mm.; ♀ 18-20 mm. Hind wings, breadth ♂ 12 mm.; ♀ 14-15 mm.

This is the most generalized species of the genus, at least of those inhabiting the United States. The two sexes are much alike, the hind wings of the ♂ being of nearly the same shape as in the ♀ and not triangular, though short, and the ♀ has much larger and longer wings, those of the hinder pair being produced toward the apex.

A male in Mr. Doll's collection, at the Brooklyn Museum, is unusually black, the strigæ on the fore wings being confluent; the outer edge of the wing is almost black-brown. The discal spots are very distinct. It was collected on Long Island.

*Egg*.—Flattened elliptical, as usual; shell thin, parchment-like, the surface marked with very obscure, irregularly hexagonal areas, which are not much crowded. Length,  $1\frac{1}{2}$ ; width,  $1\frac{1}{8}$  mm.

A lot of eggs were sent me from Albany, N. Y., by Mr. Joutel. They hatched July 14 at Brunswick, Me.

*Larva*.—*Stage I*.—Length,  $3\frac{1}{2}$  to  $4\frac{1}{2}$  and 5 mm. Head rounded, wholly black. Body pale pea-green, with a very slight, yellowish tint; abdominal legs green; thoracic legs pale, dusky amber, becoming darker toward the claws; prothoracic shield usually forming a dusky patch extending across the segment, but sometimes the shield is pale. All of the minute tubercles (spines) are green and not distinguishable from the body; they are low and minute. Those on the abdominal segments are minute, low, conical, green, and difficult to distinguish. The hairs are horn-colored. The two horns on the second thoracic segment are greenish at base, black beyond, while the setæ are black. In the living larvae they are always directed forward. They are about as long as the body is thick (Pl. L, fig. 2), and, as usual, with only the two terminal bristles. The tubercles on the segments behind the second thoracic are minute, low, with rather long setæ. The median one on segment IX is low, faint, not chitinized, giving rise to two long bristles. The suranal plate is pale, of the color of the body, not pigmented, and is rounded; the two terminal tubercles are small, weak, not chitinized, and smaller than the two on each side near

the middle. Compared with *A. virginicensis* of this stage the tubercles of the plate, as well as the rest of the body, are smaller, while those on the suranal plate are larger than in *A. senatoria*.

While at first there are no characteristic markings, at the end of this stage appear faint traces of the eight dark lines, which are more pronounced in the next stage.

One larva molted July 24, and two or three molted for the first time July 30. When about to molt it was 12 mm. in length.

*Stage II.*—Length, 7 mm.; at the end of the stage, 10 mm. Head nearly twice as large as before and still black. The body is now dark, including the prothoracic shield, and the two horns and all the tubercles are also black, as well as the suranal plate and abdominal legs, including abdominal segments 9 and 10. (Compare Pl. L, fig. 2a; LII, fig. 3a.)

At first after hatching the body is pale, the future dark portions not yet being pigmented, but toward the end of the stage the seven black lines become distinct. The spines now become large and well developed, but short. The underside of the body is livid green.

The two horns are *twice as long as in the first stage*. (Pl. LI, fig. 2.)

Of the seven dark lines or stripes the medio-dorsal or vascular line is narrow, while the one on each side is much wider; the next below (supraspiracular or subdorsal, containing the series of spines of that region) is not so wide or quite so dark as the two wider dorsal ones. The spiracular line (including the spiracles) is narrow, and a little fainter. There are no lines below this, and the underside of the body is not pigmented.

So far as I can see, the lines appear simultaneously along the whole body; they differ in intensity, becoming darker toward the middle of the stage, the pigment being deposited more abundantly after exposure to the light.

*Stage III.*—Described July 27, when just about to molt. Length, 20 mm.; length of horns, 7 mm.; width of head, 2 mm. The head is now Indian or cherry red. The body is rather dark, livid, cherry red, but without the white granulations of stage IV.

The spines on prothoracic segment black, more jagged, forked, and pointed than in stage IV (where they are rounded at the tip and bear a single seta).

The two horns with much longer, slenderer barbs than in stage IV.

Suranal plate black above, beneath reddish, the black, upper surface contrasting with the dull, reddish hue of the body. Anal legs with a large, red, triangular spot inclosed in the dark edge. The mid-abdominal legs dull cherry red, with a black spot above the planta. There are faint indications of a dark spiracular line. The spiracles are blackish, but smaller than in stage IV. (For details of the armature see Pl. L, fig. 2b, 2c; LI, fig. 2b; LII, fig. 3b.)

In stage III there is a decided change in the markings; the dark lines of stage II are now much modified. They have become faint, and only traces of them remain, while a new kind of ornamentation, the white granulations, appear. With the disappearance of the dark stripes, the traces of the two longitudinal pink lines now appear, a new plan of coloration being thus installed and not apparently inherited from a previous ancestry. The three dorsal lines are now blended together into a broad, pale, reddish band, and the pale or whitish line on each side of the head is emphasized, this becoming the upper one of the two pink lines of the later stages.

*Stage IV.*—Length, 21–25 mm.; length of the mesothoracic horns, 10 mm. The horns are longer and less spinulated than in stage III, and the body is black, dotted with porcelain-white, uneven setiferous granulations. Head Indian red or dull cherry red. *Prothoracic segment with six large stout forked spines*, where those of *A. virginicensis* are small, almost rudimentary, and they are larger than in the final stage. These spines vary, however, in being rounded, not forked, and bearing a single seta. Also the porcelain white granulations are much larger than in *A. virginicensis*. The horns on the second thoracic segment are movable and much longer than in the last stage, being nearly twice as long in proportion. The dorsal spines on all the succeeding segments are of nearly the same size, being nearly one half as long as the body is thick; those on the third thoracic segment are unevenly forked and of the same size as those of the sixth and eighth abdominal segments; those on segments 1–5 being a little smaller; those on the third thoracic segment are more regularly bifid than the abdominal ones, which have the smaller fork lower down. The single median spine on the ninth segment is no larger than either

of the two on the eighth segment, and armed with white spinules. The suranal plate black; it is rounded with six black and several white spines, the basal black ones the largest. The skin is of a peculiar blackish pitchy color. Spiracles black, with a narrow white line around them. The thoracic and abdominal legs are dark pitchy, the latter sometimes very dark red with a subplantar black patch; sides of the anal legs reddish, like the suranal plate; in other larvae the anal legs are entirely black. *No subdorsal or lateral pinkish stripe, like those in A. virginensis.*

One observed just molting from stage III, Brunswick, Me., July 27; a few minutes after exuviation the body was still of the same dull chestnut red as in stage III (though the white granulations show that it is in stage IV). One (the left) horn is shorter than the others. The spines are now all pale livid, as also the suranal plate and the anal legs. The thoracic and mid-abdominal legs are pale testaceous. In one hour it became dark and the spines black. Five more larvae had molted by July 31. (Compare Pl. L, 2c, 2d; LI, fig. 2c; LII, fig. 3c.)

*Stage V.*—Length, 35 mm.; of the second thoracic dorsal spines, 6.5 mm. The head is of the same cherry red color as in the previous stage. The second thoracic spine is about as long as the body is thick and recurved; the other spines are more curved backward and downward than in the previous stage and their shape is very different, the upper surface being smooth, the spinules being collected on the under side; the usually single large spine being white and beyond the middle, with smaller abortive spinules on the side; these spinules are larger on the spines of the eighth and ninth segments. Suranal plate reddish, its surface rough, with white piliferous granulations; near the base is a large black spine on each side, and two black ones of about the same size at the end, forming a fork; the entire tenth abdominal segment reddish. Spiracles black; a faint dusky, spiracular line. Thoracic and abdominal legs pitchy black; sides of the anal legs reddish. Skin dark, with more numerous white granulations than in the previous stage.

It is quite different and easily distinguished from *A. virginensis*; compared with this species, the head is of the same size, but the color quite different, being *dull cherry or Indian red*, while that of *A. virginensis* is yellowish amber and usually green. All the spines are much longer; those on the back of the second thoracic longer, and those behind two or three times longer; *that on the ninth abdominal certainly three times as long as in A. virginensis.* The skin is blacker, and thus the granulations are more distinct, besides being larger, while *A. stigma* *lacks the distinct subdorsal and lateral pink or flesh-colored bands present in A. virginensis.* The spines on the suranal plate are stouter and longer.

*Stage VI.*—Some specimens reared at Brunswick, Me., again molted July 30-31. The following description was drawn up August 1:

Length, 37 mm.; width of head, 4.5 mm. It differs from those in stage V in the body being dark, dusky chestnut and densely covered with porcelain-white granulations of uneven size. There is no lateral paler line such as is seen in the previous stage.

The horns are now less spiny, and all the horns and spines are shorter than in stage V. The spiracles are larger and with an outer white ring. The head, thoracic legs, and tenth abdominal segment are reddish or pale chestnut.

Two were observed moving their heads from one side to the other on being disturbed.

The following notes by Riley are added from my Forest Insects, page 126:

“*Young larva.*—August 24, 1876, found a lot of caterpillars feeding on *Quercus bicolor?* They are 0.63 of an inch in length, and of a dark greenish-gray color, with a broad dorsal line a shade darker; on each segment there are six black thorns tipped with white; two on the dorsal line, one on each side, and one on the margin of each side; those on the sides are very small and more like tubercles; thorns on the back and sides nearly equal in length, getting a little longer on the last segments; on the second segment are two very long horns, resembling very much antennae, the point of which is divided into two; they are directed forward and curved a little backward. Head brick-red, not very glossy; feet black. Destroyed by parasites. (Riley's unpublished notes.)”

“*Full grown larva.*—Average length 50 mm. General color pale tawny-red, inclining to orange. The whole surface covered with bright yellow, almost white papillæ of different sizes, giving a speckled appearance; the usual medio-dorsal narrow line; a broad subdorsal longitudi-

nal stripe of a paler color and having a dingy carneous hue; a narrower substigmatal stripe of the same hue. Horns and spines black and marked with white papillæ, and with a tendency to branch, especially toward the tips; the longer horns on joint 2 being blunt pointed, and also with white papillæ at the base. Head uniformly gamboge-yellow; cervical shield, anal plate, and plates on anal prolegs of the same yellowish color as head. A pale medio-ventral line; the thoracic legs pale, the prolegs with pale papillæ outside on a dark ground.

"The species is at once distinguished from the other species of the genus by the longer spines, their tendency to furcation, and being speckled with white papillæ, and by the less distinct striping." (Riley.)

*Aberrations in the larva.*—In different larval stages the following monstrosities or defects were observed: One is represented on Pl. LI, fig. 2, *v*, where the right dorsal horn in Stage III is about one-half as long as its mate and proportionately thicker; fig. *2a* of the same plate represents at *c* a shortened thoracic horn (Stage IV?), as compared with *d*, a normal spine; at *a* a third dorsal, and at *b* an abnormal second dorsal tubercle of a larva 12 mm. in length.

*Food plants.*—Oak, hazel.

*Habits.*—The larva of *A. stigma* is said by Doctor Riley to be nearly as destructive in the Southern States as *A. senaria* is in the Northern.

According to Abbot and Smith, in Georgia the caterpillar goes into the ground to pupate September 20 and comes forth by the middle of June following. The young at first keep together and as they grow larger disperse.

The following quotations are from Riley's unpublished notes in Packard's Forest Insects:

"Found feeding on oak and hazel at St. Louis, Missouri, by Professor Riley, on hazel in Illinois, by Mr. Muhlemann, and on both oak and hazel by Mr. Saunders, London, Ontario. Moths issue from middle of May to middle of June. Eggs were noticed to hatch July 10. Went through the first two molts till July 20, and through third molt July 27. The first larva entered the ground August 4, and the last one August 22, 1870. These are specimens from Canada, but around Kirkwood, Missouri, there are some found which are not yet full grown at this date."

"Mr. Saunders says, November 21, 1870, that he has noticed a second brood.

"According to Abbot and Smith this is the more spotted moth, and their larva agrees with mine, but is colored too yellow. Their larva of *A. pellucida* seems to differ principally in having two pink longitudinal vittæ, each side. The male and female of *A. stigma* are almost alike, while in *A. pellucida* they are unlike. Both are sometimes found on the same tree."

"Dr. Asa Fitch states that his little daughter was stung badly by a larva which he had feeding under a glass; but, notwithstanding that a slight stinging sensation is discernible, it can not be likened to that of the true stinging larva and is not more irritating than the prickly spines of *Vanessa interrogatrix*."

*Geographical distribution.*—Boston, Mass. (Harris); London, Canada (Saunders); Rhode Island (Dearden); New York (Fitch, Grote, Joutel, Beutenmüller); New Jersey (Smith); Columbus, Ohio (W. N. Tallant); Southern Illinois (French); Springfield, Ill. (June 30, July 1); St. Louis, Mo. (Riley); North Carolina (Morrison); Georgia (Abbot); Kansas (Marlatt).

It probably ranges throughout the Appalachian and Austroriparian subprovinces as far west as the one hundredth meridian; but its exact northern, northwestern, and southwestern limits remain to be defined. (See Map V.)

#### ANISOTA VIRGINIENSIS (Drury).

(Pl. XX, figs. 1, 2, 3.)

*Bombyx virginianus* DRURY. Illustratione Exot. Ent. Append., II, p. 23, Pl. XIII, fig. 2. 1773.

*Bombyx astunana* OLIVIER. Encycl. Méth., V, p. 43, No. 73. 1789.

*Phalena pellucida* SMITH-ARBOR. Nat. Hist. Lep. Ins. Georgia, p. 115, Tab. 58. 1797.

*Dryocampa virginiana* WESTWOOD. Edit. Drury, III., II, p. 24, Tab. XIII, fig. 2. 1837.

*Dryocampa pellucida* HARRIS. Rep. Inj. Ins. Mass., p. 293. 1841.—FITCH, Fifth Rep. Nox. Ins. New York, p. 44. 1859.

*Dryocampa virginianensis* WALKER. Cat. Lep. Het. Brit. Mus., VI, p. 1496. 1855.

*Dryocampa pellucida* MORRIS. Syn. Lep. N. Amer., p. 232. 1862.

*Anisota pellucida* GROTE, Proc. Ent. Soc. Phil., III, p. 93. June, 1864.

*Anisota pellucida* PACKARD, Proc. Ent. Soc. Phil., III, p. 385. Nov., 1864.

*Anisota virginiensis* PACKARD, Proc. Ent. Soc. Phil., III, p. 385. Nov., 1864.—Fifth Rep. U. S. Ent. Comm., p. 127. 1890.

*Adelocepha pellucida* BOISDUVAL, Annales Soc. Ent. Belgique, XV, p. 87. 1872.

*Anisota virginensis* KIRBY, Syn. Cat. Lep. Het., I, p. 739. 1892.—NECMOGEN and DYAR, Journ. New York Ent. Soc., II, p. 148. Dec., 1895.—BEUTENMÜLLER, Cat. bombycine moths New York, p. 440. 1898.

#### Larva.

(Pls. IV, V, figs. 1-5; XXIX, L, figs. 1-1d, LI, figs. 1-1e.)

*Smith-Abbot*, Nat. Hist. Lep. Ins. Georgia, p. 115, Tab. 58. 1797.

*Harris*, T. W., Treatise Ins. inj. veg. 3d edit., p. 407.

*Riley*, C. V., in Packard's Insects Inj. Forest Trees, p. 127. 1890.

*French*, G. H., Rep. Curator Mus. S. Ill. Normal Univ. 1880.

*Packard*, A. S., Fifth Rep. U. S. Ent. Comm. Insects Inj. Forest Trees, p. 127. 1890.

*Lugger*, O., Bull. 10. Agr. Expt. Station Minnesota, Pl. I, fig. 3. 1890.

*Beutenmüller*, W., Cat. bombycine moths New York, p. 441. 1898.

*Imago*.—5 ♂, 5 ♀ (and many others observed).

Male. Antennae bipectinated a little beyond the middle, beyond filiform; as usual in ♀ simple. Fore wings regularly triangular and smaller proportionally than in any of the other species; costa straight, curved toward the subacute apex, outer edge very oblique, not full and convex as in ♂ *A. senatoria*, but straight and nearly one-third longer than the inner edge; the inner angle less rounded than in ♂ *A. senatoria*; middle of the wing transparent from the discal spot outward to the hinder part of the outer edge and effacing the extradiscal line, except toward the apex. Discal spot nearly twice as large as in *A. senatoria* and *stigma*, being round or subovate.

Hind wings regularly triangular, costa very full; inner angle produced almost into a sort of lobe and reaching to the outer third of the abdomen; the outer edge very oblique, either a little convex or even slightly concave; immaculate, not usually, if at all, speckled, and with no extradiscal line.

Under side of wings: An extradiscal line common to both wings, though on the anterior pair effaced over the hyaline area; on the hind wings broad and diffuse, sometimes wanting. Discal spot faintly reproduced, the color paler than above.

Female. Wings not so broad as in *A. senatoria*, but of the same general shape as in *A. senatoria*, etc. In color, while the squamation is thin, as in *A. senatoria*, the wings both at the base and on the outer margin are more lilac or purple and less ocherous, while the wings are less speckled than in *A. stigma* and *senatoria*, the outer edge not being spotted. Extradiscal line diffuse, not very distinct or dark. Discal spot slightly larger than in *A. stigma* and *senatoria*, under side pale ocherous; outer edge of both wings deeper lilac than in *A. stigma* and *A. senatoria*. Hind wings more convex toward the base of the costa than in any of the other species. Beneath not spotted. The abdomen is much paler than in ♂.

Expanse of fore wings ♂ 40-42 mm.; ♀ 50 mm. Length of a fore wing ♂ 18-20 mm.; ♀ 26 mm. Breadth of a fore wing ♂ 8-9 mm.; ♀ 13 mm. Length of hind wing ♂ 11-12 mm.; ♀ 17 mm. Breadth of hind wing ♂ 7-8 mm.; ♀ 11-12 mm.

This species differs markedly from any of the others in the characteristics of the male, whose narrow fore wings are regularly triangular, while those of the hinder pair are triangular, much rounded on the costa, with the inner angle produced, almost into a lobe. The ♂ is thus the most divergent of any species of the genus, but in the shape of the wings only. Another characteristic is the thinness and transparency of the fore wings beyond the discal spot, which is larger than in any of the other species. The less divergent female differs from those of *A. stigma* and *A. senatoria* in the stronger lilac hues and in the absence of the dusky striga.

"Moth.—Besides being smaller, the male differs from those of *A. stigma* and *senatoria* in the hind wings being distinctly triangular, the outer edge being straight, and the hind angle somewhat produced; the fore wings are also decidedly narrower, while the white discal spot is considerably larger, and the wings are throughout considerably darker and free from dark spots. Expanse of wings of male, 40 mm." (Riley).

*Larva*.—*Stage I*. Length 6-7 mm. Head black, as wide as the body. Prothoracic plate dark chestnut, almost black. The two horns on the second thoracic segment black, as well as the conical spines on the abdominal segments 9 and 10.

At the beginning of the stage the body is considerably darker than at the end, where it is amber or pale gamboge or of the color of beeswax (Pl. IV, fig. 1), with faint traces of two lateral pale, yellowish lines, which are more pronounced in the next stage.

The two horn-like spines on the second thoracic segment are but little longer than the segment bearing them is wide, or than the maximum thickness of the body.

The conical dorsal tubercles on the abdominal segments are moderately high and distinct, and are one-half smaller than those on the third thoracic segment.

Suranal plate and the triangular area on the outside of the anal legs black, while the rest of the anal legs is pale, greenish yellow. The suranal plate is cordate. For the shape and armature see Pl. LII, fig. 1.

*Stage II*. Length, 7 mm. Head large and full, dark umber, wider than the middle of the body. The prothoracic segment is broad, with the front and sides flaring; upper surface dark chestnut. Body chestnut-amber. From the second thoracic segment two very long, sparsely spinulate, black horns arise, which are nearly half as long as the body; they are a little flattened at the tip, ending in two piliferous tubercles. There are on all the other segments six rows of conical acute black tubercles; the eighth segment is armed exactly as the seventh. All these tubercles are distinctly larger and more prominent than in Stage I. On the ninth is a single median spine. The tenth segment, or suranal plate, is paler than the body, and near the edge are six whitish tubercles, and at the end are two long, piliferous tubercles. The spiracles are white, distinct, being ringed with black. The thoracic and middle abdominal legs are black; the anal legs of the same varnish-colored tint as the suranal plate. The skin of the body is rough, with two lateral ridges, on the upper one of which the spiracles are situated and on the lower a spine. Across each segment behind the spine is a transverse row of small whitish warts, and other granulations are scattered over the body. The caterpillar is dark and a somewhat conspicuous object on an oak leaf. Received from Providence, R. I., July 1. It molted about July 14 or 15.

In the examples of this stage drawn by Mr. Joutel the head is dull raw sienna brown, the prothoracic shield brown, while the second thoracic segment above is, directly after hatching, reddish brown. The two lateral lines (subdorsal and infraspinaular) are pale and faintly indicated. The larva differs from Stage I in the pale-brown head, pale suranal plate and anal legs, and in the broad dusky dorsal band and more distinct lines.

*Stage III*. Length, 15 mm. Head light chestnut, slightly narrower than the body, which is now colored somewhat like the full-fed larva, though only the lower pinkish line is clearly indicated, the subdorsal pink line being narrow and faint. The two horns on the second thoracic segment are now much shorter in proportion, being one-third longer than the segment is wide, or as long as the second and third thoracic and first abdominal segments taken together. The color of the body is nearly the same, but the white granulations, very unequal in size, are more distinct than before. The spiracles are wholly black, and situated between two indistinct broken white parallel lines. The black dorsal spines on the third thoracic and first abdominal segments are smaller than those on the other abdominal segments; those on the eighth and ninth segments are of the same size and larger than those on the other abdominal segments. The suranal plate and anal legs are pale amber, much paler than the rest of the body. The plate has two black conical spines, one on each side. (Pl. LII, fig. 1*a*). It molted July 22, having been about seven days in this stage.

*Stage IV*. Length, 21 mm. Head as before, as wide as the body in the middle, but now greenish, as in the last stage. Some new marks now appear; there is a broad, dorsal, dark, longitudinal band composed of a series of square dark patches, sprinkled over with thickened white granulations, and a subdorsal band of the same color, composed of oblong dark patches, bearing a spine above, and on the lower edge the black spiracle, situated on a white field. The skin is of the color of beeswax; in some specimens decidedly greenish in hue. There is a median black forked spine on the ninth abdominal segment. The suranal plate is as before, but the

tubercles are long and slender, rounded at the tip, and porcelain white. The two spines at the end of the suranal plate are tipped with black, this plate and the anal legs being paler than the body. The horns on the second thoracic segment are now shorter than before, or as long as the third thoracic and first abdominal segments taken together. They are, however, longer than in the last (fifth) stage, with longer spinules, and end in two diverging spinules. The other spines are as before, those on abdominal segments 4-8 being larger than those on the three segments in front. The two pink lines are now more distinct from above as well as from the side; the prothoracic plate is still blackish-brown. The legs, both thoracic and abdominal, are now pale greenish, much as in the fifth and last stage.

In one larva of Stage III the lateral pink line is only present on the abdominal segments, suggesting that the lines originate at the end of the body and become developed from behind forward.

In this (third) stage the dark stripes are more distinct and definite than in the corresponding stage of *A. stigma*. What corresponds to the three dorsal lines of the second stage of *A. stigma* are already blended into a broad dark dorsal band. The two lateral lines (spiracular and supra-spiracular) are still distinct.

The white granulations are, on the back above the spiracles, transversely oval, and arranged in transverse series, but below the spiracles they are round and show a disposition to be arranged longitudinally.

*Stage V and last.*—Length, 55 mm. Head greenish yellow or green in life, in the blown example pale sienna brown, or yellowish chestnut; three-fourths as wide as the body where thickest. The prothoracic plate is now not black as in Stage IV, but concolorous with the rest of the body, and bearing near the front edge four dark flattened tubercles.

The two horns on the second thoracic segment are now shorter than in Stage IV, and differ in shape (Pl. L, fig. 1c); the tip is bulbous, smooth, and destitute of the two terminal setae present in the previous stages; the spinules on the trunk are short and blunt compared with those in Stage IV. The horns vary in thickness (Pl. L, fig. 1c, 1d).

The two dorsal spines on the third thoracic segment are short, when longest no longer than the thickness of the horns at base; they are about three times as long as thick at the base, and are bifid at the tip, each fork ending in a short stout seta. The two dorsal spines on the first abdominal segment are minute, shorter than those on the second abdominal segment; the latter are a little longer, simple, and the corresponding spines increase in length to the ninth segment, those on the eighth and ninth segments being the longest; those of the infraspiracular series on the eighth and ninth segments are bifid.

The suranal plate pale dull amber, and bearing two stout black conical spines, one on each side, and not quite halfway from the base to the end of the plate; smaller tubercles are scattered over the surface, but are larger at the edge of the plate. The plate ends in two slightly diverging large conical tubercles, about twice as long as thick at the base, and twice as long as any others on the plate, and bearing on the sides three or four setiferous tubercles (Pl. LH, figs. 1b, 1c). Compared with those of *A. stigma*, these two terminal tubercles are larger.

Anal legs of the same color as the suranal plate, with white tubercles on the edge around the central area. The body is greenish on a grayish parchment-colored ground, scattered over rather densely with white granulations, which have a central pit, and in some cases a vestigial seta. The amount of green varies.

From the prothoracic to the ninth abdominal segment two broad distinct deep pink stripes; the upper or subdorsal one situated on the subdorsal row and supra-spiracular row of spines, the lower between the spiracles, nearly touching them, the spines of the infraspiracular series being situated in the middle of the pink stripe. The amount of pink in these bands varies.

The thoracic legs pale; those of the mid abdomen pale, with a dark spot on the outside above the plate.

The full-fed larva differs from that of *A. stigma*, with which it is liable to be confounded, in the shorter spines. (See the figures of structural details in Plates L, LH.)

We add also the following description, furnished by Doctor Riley, who has compared it with the caterpillar of *Anisota stigma*:

"*Pellucida* comes nearest to *A. stigma* in general appearance, but the spines are shorter, more pointed, uniformly black; the color is darker, being almost black, so that the papillæ, which are rather denser, give the dark portion a bluish cast; the subdorsal and stigmatal lines are of a more intense red, inclining to pink, and the stigmatal line is rather broader than the subdorsal. The average length is somewhat less and the larva more slender than in *stigma*; the shorter, blacker spines, deeper colors, and stronger contrast between the lines at once separating it from *stigma*."<sup>a</sup>

Specimens, without much doubt belonging to this species, though we have not found the moth in Maine, occurred on the red oak at Brunswick, Me., August 28. The body was greenish, with dark dorsal and lateral, not "reddish," bands.

*Pupation*.—One larva 25 mm. in length pupated about September 12-14. In casting the larval skin the head split along the middle from the front edge, on the left side of the clypeus up along the median suture, and through the median line of the thoracic segments to a point half through the 3d abdominal segment.

*Variation*.—From the batch of eggs received from Albany, N. Y., about 250 larvae hatched. The entire number did not show any perceptible variation in color or in the length of the horns. They had been placed in a gauze bag tied on the end of a small oak tree; but they soon crawled out of the bag and were found huddled up together on the under side of a leaf.

Mr. Joutel informs me that the larvae of the first stage are all similar in color in all he raised, but the other stages vary in the amount of pink in the stripes, some in the third stage showing only a slight trace of it; they also vary in the amount of green.

*Pupa*.—♂. The body is slightly slenderer than in the ♂ of *A. rubricanda*, the spines not quite so stout, while the cremaster is not quite so thick; the surface has similar punctures; otherwise the characteristics of the species are those of the genus. Length, 23 mm.

*Food plants*.—Oak of different species.

*Habits*.—This species (*A. virginiana*) has been said by Fitch to have been common for many years in Salem, N. Y., where *A. stigma* has seldom been seen. The larvae mostly enter the ground to transform into the pupa early in August, though some remain on the trees as late as the middle of September.

*Parasites*.—*Limneria fugitiva* Say attacks the caterpillar when about one-third grown, a single egg being deposited in each caterpillar, the larva spinning a slight cocoon within its host. A Tachina oviposits several eggs, usually in the neck of nearly full-grown caterpillars.

*Geographical distribution*.—Brunswick, Me. (Packard); Plattsburg, N. Y. (Hudson); Boston, Mass. (Harris); Williamstown, Mass. (Grote); Attleboro, Mass., June 18 (Packard); New York (Grote, Elliott); Rhode Island (Clark, Dearden); Columbus, Ohio (Tallant); New Jersey ("comparatively scarce," Smith); Maryland (Streeker); St. Louis, Mo., and Virginia (Riley); Minnesota (Lugger); Georgia (Abbot). (See Map IV.)

#### ANISOTA CONSULARIS Dyar.

*Anisota consularis* DYAR, Journ. N. Y. Ent. Soc. IV, p. 166, Dec., 1896. List N. A. Lep., p. 75, 1902.

*Larva*.

(Pl. V, fig. 8.)

*Imago*.—Male: smaller than the female; body ochreous brown, wings dark purplish brown, a larger ill-defined subhyaline space in the center of the fore wings; a round white discal dot. Terminal space more purplish than the basal part of the wing.

<sup>a</sup> Found on different kinds of oak, October 2, 1873, many larvae looking like *D. stigma*. The form is the same, but they differ considerably from them in color and markings. It is to be distinguished from *D. stigma* in its smaller size, in the ground color of the dark parts being blacker, the papillæ being yellow instead of white, and in the paler vittæ being of a deep pink or lake-red. The head and anal shield are more olivaceous, and the spines are shorter and stouter. The whole larva is more brightly and distinctly marked. Moths issued April 22, 1874.

Some of the dried larva skins were brought from Loudoun County, Va., in July, 1881. (Riley's unpublished notes.)

"Closely resembles the male of *A. senatoria* in color, but the hind wings are rounded as in the female, not angulated at apex and anal angle, and the t.-p. line is much more obscure."

"Female: wings purplish brown, basal and terminal spaces darker; a white discal dot and faint blackish striga. Hind wings with a purplish mesial band."

"Darker than either *senatoria* or *stigma*, the lines less distinct; wings opaque, not thinly scaled as in *virginianensis*. Types male and female, bred from larvae."

This species also differs from *A. stigma* in the extradiscal line passing much nearer the discal spot, and in being decidedly incurved. The white discal spot is smaller and the wings more opaque.

"*Larva*.—Primary spines black, secondary granules sparse, white. Head shining red-brown, width 3.5 to 4 mm. Body red-brown, a dorsal, subdorsal (i), lateral (iii), stigmatal, and subventral clouded black bands. Dorsal and stigmatal bands harp [dark?] and narrow, the others clouded, the subventral filling the whole space. All except the subventral are bordered by white shaded lines on the lower side, that below the stigmatal line very distinct. All the lines become obsolete on joint 12, leaving the anal end and all the feet red-brown. In large examples the skin has a fleshy tint, different from the head and plates, while the shaded lines tend to be broken at the primary spines."—(Dyar).

*Food plants*.—Live oak.

*Habits*.—Found by Doctor Dyar on the live oak in January in company with those of *A. stigma*, etc. The larva of this species is represented on Pl. V, from a colored drawing made by Mr. Joutel and kindly loaned me by Doctor Dyar.

*Geographical distribution*.—West Palm Beach, Florida (Dyar).

#### ANISOTA SENATORIA (Smith-Abbot).

Pl. XX, figs. 10, 11♀, 12♂.

*Phalaena senatoria* SMITH-ABBOT, N. H. Lep. Ins. Georgia, p. 113. Tab. 57, 1797.

*Anisota senatoria* HÜBNER, Verzeichniss, Schmied., p. 193. 1818-1822.

*Dryocampa senatoria* HARRIS, Cat. Insects Mass., p. 72 (p. 592), 1835; Rep. Inj. Insects Mass., p. 292. 1841. Third edition, p. 405, fig. 200. 1862.—WALKER, Cat. Lep. Het. Brit. Mus., VI., p. 1496. 1855.—FITCH, Fifth Rep. Nox. Insects New York, p. 43. 1859.—MORRIS, Synopsis Lep., p. 231. 1862.

*Anisota senatoria* GROTE, Proc. Ent. Soc. Phil., III, p. 93. June, 1864.—PACKARD, Proc. Ent. Soc. Phil., III, p. 384. Nov., 1864.—KIRBY, Syd. Cat. Lep. Het., I, p. 739. 1892.

*Adelocephala senatoria* BOISDUVAL, Annales Soc. Ent. Belgique, XV, p. 87. 1872.

*Anisota senatoria* NEUMOGEN and DYAR, Journ. N. York Ent. Soc., II, p. 147. Dec., 1894.—BEUTENMÜLLER, Cat. bombycine moths N. York, p. 439. pl. xx, fig. 3♂. Oct., 1898.

#### *Larva*.

Pl. VI: XXXI, figs. 2-4; XXXII, fig. 1; LI, figs. 1, 3, 3a, 3b, 3c; LII, fig. 2; LIII, figs. 1, 1a-1f.

*Smith-Abbot*, Nat. Hist. Lep. Ins. Georgia. p. 113. Tab. 57, 1797.

*Harris*, T. W., Treatise Ins. Inj. Veg., 3d edit., p. 405, fig. 198; pupa 199. 1862.

*Riley*, C. V., in Packard, 5th Rep. Ins. Forest Trees, p. 124. 1890.

*Boisduval*, J. A., Annales Soc. Ent. Belgique, XV, p. 87. pl. III, fig. 5. 1872.

*Logger*, O., Bull. 10 Agr. Expt. Station, Minnesota, pl. i, fig. 12. 1890.

*Felt*, E. P., 7th Rep. Forest, etc., Comm. N. Y., pl. 16, figs. 1-7. 1903.

*Packard*, A. S., Proc. Amer. Phil. Soc., p. 144. March 17. 1893.

*Beutenmüller*, W., Cat. bombycine moths N. York, p. 439. 1898.

*Imago*.—10♂, 10♀. The characters of this species are best brought out by a comparative description, as the females of this and *A. stigma* are scarcely distinguishable.

The ♂ differs from that of *A. stigma* in the hind wings being distinctly triangular, the apex being less rounded, and the outer edge of the wing not so convex, while the inner angle is slightly produced; the wings reach only two-thirds of the length of the abdomen; they do not extend back so far as in *A. stigma*.

In one ♂ from Rhode Island the hue is fully as dark as in ♂ *A. stigma* from southern Illinois, and the discal spot is as large. The common extradiscal line is quite heavy, being on the hind

wings broad and distinct. Underside as above, but no paler; the outer edge of the fore wings is deeper like than above, though becoming dark ocherous toward the inner angle. There is little difference in the number and distribution of the striae.

♀, fore wings paler, thinner in the middle than in ♀ *stigma*, and it is a rather smaller moth; the wings are less striated or speckled, the specks being fewer and less distinct. The discal spot is the same. The body and wings paler ocherous. Hind wings with the extradiscal line obsolete above, but fairly distinct below. In shape they are exactly as in *A. stigma*.

Expanse of the fore wings ♂, 43 mm.; ♀, 50–54 mm. Length of a fore wing ♂, 22 mm.; ♀, 24–26 mm. Breadth of a fore wing ♂, 10 mm.; ♀, 13–15 mm. Length of hind wing ♂, 14 mm.; ♀, 15–17 mm. Breadth of hind wing ♂, 11 mm.; ♀, 11–13 mm.

*Egg*.—“August 4, 1869, received of F. A. Gates, Massillon, Cedar County, Iowa, a ribbed female of *Dryocampa senatoria* with a batch of over 300 eggs on the underside of a raspberry leaf. These eggs are almost round in outline, depressed, being about half as high as wide, the width across being 0.04 of an inch. The shell is so very transparent that it makes a very good object for watching the development of the embryo. The egg when first laid is yellow, with a darker brownish ring above.”—(Riley).

Riley states that the female lays a batch of over 300 eggs, in the case observed, on the underside of a raspberry leaf.

Lugger found from 350 to 675 eggs in a cluster. He says they are very beautiful objects, “both when fresh and after having hatched; in the former case they are of a pale green, and change later to a golden brown. The eggshells are very thick, transparent as glass, and if the young caterpillars have left the eggs, the empty shells look like iridescent glass.”

The larvae hatched August 1 and 2.

*Stage I.* Length, 3.5–4.5 mm. Head large, round, smooth, wholly black, a little higher than wide; when seen from in front a little wider than the body. Prothoracic segment a little wider than the second thoracic segment; smooth, unarmed, but with a transverse dusky patch extending across it. The second thoracic segment bears a pair of high smooth clavate spines or horns which are a little longer than the head is wide and each bearing two terminal bristles of equal length. They are unarmed, no spinules visible under a lens. The spines on the other segments are black, being of the same color as the thoracic legs. The body is *wholly greenish yellow*, with long, rather pale, yellowish-brown hairs arising from conical tubercles.

The end of the body is a little more yellowish than toward the head.

Thoracic legs dark; abdominal legs all of the same color as the body. Suranal plate smooth, pale, not granulated; the two terminal spines minute, weak; the plate is soft, thin, not pigmented, anal legs pale, like the rest of the body. The two median setae on segment 8 arise from a common base, but are much as in *A. rubicunda*, Stage I. (See Pl. LI, fig. 3; LIII, fig. 1.)

August 4 the same larvae had become 5.5 mm. in length. The body was now *green*, with no yellow tints, and the two horns are *black*. The head is scarcely as wide as the body, and the hairs are greener and less conspicuous.

*Stage II.*—August 10–12. Length, 7–8 mm. *Head, prothoracic segment above and horns, with the suranal plate and anal legs jet-black.* The prothoracic shield is now present and black-pigmented around the edge and along the middle (fig. 3 a). The body is now *dark green with yellowish-green lateral lines and black conical acute warts*. A median dorsal dark line; a subdorsal pale yellowish-green line, and below it a lateral wider line of the same hue, separated by a very narrow dark-green line from a broad lateral line which includes the lateral swollen ridge, and a row of conspicuous black tubercles. Under side of body dark green. The tubercles on the eighth and ninth segments larger than those in front. Suranal plate rough, tuberculated, the two terminal spines being now large and prominent, black; it is much specialized and pigmented, while the two terminal spines are several times larger than in Stage I. Thoracic horns large, long, black, nearly twice as long as the body is wide, and one-third longer than the head is wide; they are now finely spinulated, and less bifid at the end than in Stage I. Thoracic legs black; abdominal feet dark green, except the anal pair, which are black.

The two median setae on ninth segment are separate, but arise from a slightly marked common base, as in Stage I. The skin is now finely spinous, the short spinules acute. (See Pl. LI, fig. 3*a*; LIII, fig. 1*a*.)

*Stage III.*—August 20. Length, 13–17 mm. The specific characters now appear, so that the larva may be easily identified. The black head is slightly narrower than the body. Prothoracic plate distinct, entirely black, spinose on front edge. The thoracic horns are black, one-third longer than the body is thick. The body is dark yellowish green, or rather olive green, *with two narrow yellowish dorsal lines*, and a subdorsal and a lateral yellowish line on each side; the underside of the body is green. The spines are a little longer and sharper than before, otherwise the larva is much as in Stage II, though the median spine on eighth segment is now chitinized, solid, and black and as high as the diameter is broad (Pl. LIII, fig. 1*b*).

Suranal plate black, more spinose, the surface tubercles being larger and more prominent.

*Stage IV.*—August 22–23. Length, 20 mm. Now the characters of the next last stage appear. The body is entirely black, with four yellow stripes on each side, the subdorsal line being the widest and firmest, and the infraspirecular line the most irregular and broken. The under side of the body is dull blackish. The horns are now a little larger and stouter than in Stage III. The prothoracic plate has a line on each side. The suranal plate and sides of the anal legs are sharply spinose, and the median spine on the ninth abdominal segment is higher, more prominent than in Stage III (Pl. LIII, fig. 1*c*–1*e*).

*Stage V.*—Length, 42–45 mm. The body is thicker and larger than in *A. rubicunda*. Head black. Body and the prothoracic shield black, the surface of the plate rugose, with the spines on the front edge low, smooth, not so well defined as in *A. rubicunda*, as they are lower, while the surface of the plate is rough with small short spines. The two horns are a little thicker and longer than in *A. rubicunda*, rounded, not slightly forked at the end as in the previous stages, but slightly bulbous; they are also rougher than usual on the surface, with rather stout, firm, nearly atrophied spinules. The skin all over the body is rough, with numerous fine granulations, bearing short minute setae, the granulations in the other species not being so acute, and being mostly without a seta.

The ground color is black-brown; there are eight longitudinal deep yellow ocherous stripes, the two dorsal ones narrowest; in one example wider than any of the others; the subdorsal one is straight, while the next one below (supraspiracular) is undulating; the one still below that (infraspirecular) bearing the infraspirecular row of spines is divided by a narrow, irregular dark line. A ventral yellow-ocher median stripe. The spiracles are black.

The dorsal spines on the third thoracic segment are minute, low, not so high as thick, not ending in a single spine, but are forked, ending in two short, sharp spinules. On abdominal segments 1–7 the dorsal spines are small, sharp, those on the seventh segment a little larger than those on the preceding segments. Those on segments 8 and 9 (Pl. LII, fig. 2; LIII, fig. 1*f*) are decidedly larger than in *A. rubicunda*, and much heavier and larger than in stage IV. The four infraspirecular ones on segment 8 are of the same size, sharp, nearly twice as long as broad.

Those on the ninth segment are from one-third to one-half larger than in *A. rubicunda*, and much larger and higher than in stage IV. The median one is a little more prominent than the others, and decidedly forked at the end. The suranal plate is subcordate, with the two terminal spines larger, though but little larger than the two on each side near the base, these belonging to a group of three or four on each side, situated a little in from the edge near the base; the surface is rugose, and with several spines differing in size (fig. 1*f'*). The anal legs are blackish, with numerous uneven spines around the edge, while over the central area are scattered fine depressed spinules. All the spines, including the two horns, are stouter in proportion than in any other species. Thoracic and abdominal legs all black, including the anal claspers.

This is a very distinctly marked and colored species, and is easily recognized by the larger, coarser spines and the alternating black and deep ocher yellow stripes.

Another set of larva received from Mr. Joutel, New York City, and reared at Brunswick, Me., had already hatched July 29. They first molted August 9–10, the length between the molts being nearly the same as in the brood from Providence.

Riley thus describes (in our Report on Forest Tree Insects, p. 125) the fully fed larva received by him from Cedar County, Iowa:

"*Larva*.—Head large, fully as wide as the body; jet black. Body uniformly thick, cylindrical. On mesothoracic segment a pair of long and slender, stiff, black spines, blunt at the end, nearly as long as the body is thick. They stand erect, diverging a little, and arise from swollen bases, connected by a slight transverse ridge. On each succeeding segment there is a transverse series of four small, sharp, simple spines, one or two sometimes ending in two spines; and low down on each side, below the spiracles, are three large and a fourth minute short acute spine.

"There are on the hinder part of the back of most of the segments two small black spines. The spines become larger on the last three, especially the penultimate segment. Supraanal plate large and flat, rather rough, ending in two acute spines, with four smaller spines on each side. Abdominal legs larger and broad, with stiff short hairs on the hinder and lower edge.

"Prothorax unarmed, but with a thickened conical plate. Body jet-black, with a double dorsal ochre-yellow-brown line, a narrow subdorsal line, and two wavy lateral lines of the same color. A median ventral ochre-brown band. Length, 42 mm."

*Food plants.*—Oak of different species and, rarely, the birch and raspberry.

*Habits.*—The prickly caterpillars of this species, during certain years, as I have noticed at Amherst, Mass., and at Providence, as well as in Maine, so abound as to nearly strip large oak branches of their leaves, and it is perhaps the most destructive of all our caterpillars to the foliage of the oak. The spines, if they happen to penetrate the skin, as Fitch and others have observed, sting like nettles. This species, Mr. Riley informs me, is the more injurious in the Northern States, while *A. stigmata* is most destructive in the Southern. According to Riley, Mr. Bassett has bred a small ichneumon fly (*Limneria (Banchus) fugitiva* Say) from this caterpillar. Riley has also bred it from the larva of *Anisota stigma*, *Civisicampa sylvaria*, as well as other caterpillars.

Mr. Lintner states that "the larvae occur so abundantly at Center as wholly to defoliate numbers of the smaller oaks. On the 7th of July the female moths were seen to have commenced the deposition of their eggs on the under side of oak leaves in patches often nearly covering the entire surface. On the 11th of July some newly hatched larvae were observed." (Ent. Contr., I, p. 58, footnote 1.)

In 1882 this caterpillar was very destructive to oak forests in Pennsylvania. Professor Claypole writes to the Canadian Entomologist (XV, p. 38):

"I have seen hillsides that looked as if fire had passed over them in consequence of the destruction of the foliage by millions of this species. In the woods they could be found crawling over almost every square foot of ground and lying dead by dozens in every pool of water. The sound of their falling "frass," too, was like a slight shower of rain. Farmers tell me they have never known them so abundant before within their recollection. Harris says this species lives on the white and red oaks in Massachusetts. Here the white oaks were untouched and the red oak is not abundant. The food of the caterpillars was almost exclusively the foliage of the black oak (*Quercus velutina*), the scarlet oak (*Q. coccinea*), and the bear or scrub oak (*Q. ilicifolia*). (See also American Naturalist, XVI, p. 914.)"

It was also abundant in September of the same year in Sagadahoc and Cumberland counties, Me., and in Rhode Island.

In the season of 1882 F. Clarkson observed the destruction to oaks in Columbia County, N. Y. "The moths," he says, "pair in the grass under the oaks, very shortly after pupation, and as the wings of the female are small in proportion to the size of her body, she is unable to make a very extended flight. The eggs, as discovered by me, were attached to the under side of the leaves at the terminal twigs of all the branches nearest the ground, the branches at an elevation of 12 or 15 feet not showing a single deposit." (Papilio, II, p. 189.)

In Minnesota the caterpillar is regarded as the most common and injurious insect to oaks in the State, white, scarlet, and scrub oaks being stripped of their foliage. "I have seen," says Lugger, "such caterpillars so numerous that the whole ground in the forests was covered

with these crawling insects, running about in all directions to find food, which the trees, already denuded of foliage, no longer afforded. They are found in large numbers every year and seem to prefer, if not too numerous, the smaller trees. The rather large, flat eggs of this moth are deposited early in July, and always in large, irregular clusters on the under side of a leaf, and almost invariably near the tip of a branch."

"The young caterpillars appear toward the end of July, but sometimes much later—so late, in fact, that the mature ones find it difficult to obtain the necessary food among the discolored autumnal leaves. The young caterpillars are gregarious and feed only at regular intervals, huddling together at other times. The younger and more tender leaves near the ends of branches are first eaten and nothing of them remains but the midrib and stem, and in some cases the leaf beneath the empty shell, . . . As the caterpillars grow larger the colony separates into smaller families, and when the worms reach their full size they scatter more and more, forced to do so by their ever increasing appetite. Before reaching their full size they undergo a number of molts. Their empty skins are not eaten or thrown away, which is very frequently the case with caterpillars, but remain for a long time upon the ribs of the under side of a leaf, to which the caterpillar had fastened itself very securely before undergoing a molt. The skin of these caterpillars is remarkably hard and stiff, which accounts for the peculiarity of leaving the empty skin behind, as if inflated. Although gregarious, they do not form a web of any kind."

*Parasites*.—*Limneria fugitiva* Say, and a Tachina (Lugger).

*Geographical distribution*.—Island of Orleans, Province of Quebec, Canada, very rare (Hammond Bowles); Sagadahoe and Cumberland counties, Me., abundant; Amherst, Mass., Providence, R. I. (Packard); Boston, Mass. (Harris); near Albany, N. Y. (Lintner); Pennsylvania (Claypole); New Jersey ("common," Smith); St. Louis, Mo., Cedar County, Iowa (Riley); Minnesota (Lugger); Georgia (Abbot). A member of the Appalachian and Austroriparian subprovinces; its northern and southwestern limits can not yet be exactly defined. (See Map VII.)

#### ANISOTA RUBICUNDA (Fabricius).

(Pl. XX, figs. 15, 15a, 15b.)

*Bombyx rubicunda* FABRICIUS, Ent. Syst., III (1), p. 429, n. 69. 1793.

*Dryocampa rubicunda* HARRIS (in Hitchcock's Report on the Geology, etc., of Massachusetts, 4<sup>th</sup>, p. 592, 1834, and 2d ed., 1835), Cat. Ins. Mass., p. 72. 1835; Treatise Inj. Insects, 3 ed., fig. 206, p. 408. 1862.—

WALKER, Cat. Lep. Het. Br. Mus., VI, p. 1497. 1855.—MORRIS, Synopsis Lep. N. Amer., p. 232. 1862.

*Anisota rubicunda* GROTE, Proc. Ent. Soc. Phil., p. 93. June, 1864.

*Dryocampa rubicunda* PACKARD, Synopsis Bombycidae U. S., II, Proc. Ent. Soc. Phil., p. 384. Nov., 1864.

*Dryocampa venusta* WALKER, Suppl. Cat. Lep. Het. Br. Mus., 2 (32), p. 574. 1865.

*Adelocophala rubicunda* BOISDUVAL, Annales Soc. Ent. Belgique, XV, p. 88. 1872.

*Dryocampa* (*Anisota*) *rubicunda* RILEY, 5th Ann. Rep. Ins. Missouri, p. 137, fig. a, b, c. 1873.

*Dryocampa rubicunda* var. *alba* GROTE, Bull. Buffalo Soc. Nat. Sc., II, p. 183. 1874.

*Dryocampa pallida* BOWLES, Can. Ent., VII, p. 108. 1875.—BEUTENMÜLLER, Cat. bombycine moths N. York, p. 440. 1898.

*Dryocampa rubicunda* PACKARD, 5th Rep. U. S. Ent. Comm. Ins. Inj. Forest Trees, p. 392. 1890.—KIRBY, Syn. Cat. Lep. Het., I, p. 739. 1892.

*Anisota rubicunda* NEUMOGEN and DYAR, Journ. N. Y. Ent. Soc., II, p. 148. Dec., 1894.

*Anisota rubicunda* var. *alba* NEUMOGEN and DYAR, Journ. N. Y. Ent. Soc., II, p. 148. Dec., 1894.

<sup>a</sup> *Anisota senatoria* Abbot & Smith (Nat. Hist. Lepid. Ins. Ga., 1797, v. 2, p. 113, pl. 57). Harris (Rept. Ins. Injur. Veg., 1841, p. 291, 292) describes the larva, pupa, and imago of this species; the larva, he states, feeds upon white and red oaks [*Quercus* sp.]. Morris (Synop. Lepid. N. A., 1862, p. 231) describes the larva and imago. Harris (Treatise on Ins. Injur. Veg., 1862, p. 405, 406) figures and describes larva, pupa, and imago, and (Entom. Corresp., 1869, p. 298, pl. 2, fig. 9, and pl. 4, fig. 12) gives a colored figure of the larva and a black one of the pupa. Riley [?] (Amer. Entom., Sept.-Oct., 1869, v. 2, p. 26) states that the larva eats raspberry [*Rubus* sp.]. Lintner (Entom. Contrib., No. 2, 1872, p. 51, 52) describes the early stages of the larva, which, he writes, has four molts (five stages), and feeds on *Quercus prinoides*. Packard (Bull. 7, U. S. Entom. Comm., 1881, p. 45) briefly describes the larva, and gives a few notes upon its habits. The larva feeds on *Betula alba*. (Mrs. Dimmock, Psyche, IV p. 275.)

*Larva.*

(Pl. VII; XXIII, fig. 2; XXXII, figs. 2, 3; LII, figs. 4, 4a-4d; LIII, figs. 2, 2a-2c.)

- B. D. Walsh (description by Lintner). Proc. Ent. Soc. Phil., III, p. 426. 1864.  
 W. Saunders, Can. Ent., II, p. 75. 1870.  
 T. Glover, Rep. U. S. Dept. Agr., p. 83, fig. 1870.  
 J. A. Lintner, 26th Rep. N. Y. State Cab. Nat. Hist., p. 133. 1872.  
 C. V. Riley, 5th Rep. Ins. Missouri, p. 137. 1873. Fig. of larva, pupa, and moth ♀.  
 C. H. French, Trans. Dept. Agr. Illinois, XV, p. 196. 1877.  
 A. R. Grote, Can. Ent., XIX, p. 52. 1887.  
 Mrs. Ballard, Insect Lives, p. 83. 1879.  
 J. Marlow, Trans. Dept. Agr. Illinois, XVIII, Appendix, p. 121. 1880.  
 A. S. Packard, 5th Rep. U. S. Ent. Comm. Insects Inj. Forest and Shade Trees, p. 393, fig. ex Riley. 1890.  
 A. S. Packard, Proc. Amer. Phil. Soc., Mar. 17, 1893, XXXI, No. 141, p. 142-144, Pl. V, fig. 1. Larva, stage II.  
 W. Beutennüller, Cat. bombycine moths N. York, p. 440. 1898.

*Imago.*—5 ♂, 5 ♀. Head and body uniformly pale ocherous, varying in depth of hue. The front of the head below the vertex and the spreading tuft of hair-like scales at the base of each antenna rose pink.

Fore wings deep roseate on the basal half, the hue varying from light to dark; the outer edge of the wing also roseate from about the middle of the inner edge to the costa just before the apex, the middle of the wing being yellow; and this subtriangular median band varies in width, sometimes being wide on the inner edge or not reaching clear across the wing to the inner edge; the band also varies in regularity on the inner side; no discal spot; fringe pale ocherous.

Hind wings yellow ocherous, with a submarginal pink band, narrow in the middle of the wing and widening on the inner edge. Underside of the fore wings much as above, but less roseate at the base of the wings. Hind wings with the entire costal edge pink, otherwise as above. Abdomen on the underside along the middle pink, but ocherous at the end. Legs all pink.

Expanse of fore wings, ♂ 40 mm.; ♀ 48 mm. Length of fore wing, ♂ 29 mm.; ♀ 24 mm. Breadth of fore wing, ♂ 10 mm.; ♀ 12 mm. Length of hind wing, ♂ 13 mm.; ♀ 16 mm. Width of hind wing, ♂ 10 mm.; ♀ 12 mm.

*Variations.*—One ♂ from Franconia, N. H., received from Mrs. Slosson, is paler, less ocherous, almost cream white, more bleached in appearance and with less roseate, and the pink paler than in the normal form. Fore wings with an extradiscal narrow pink line, but beyond this the edge of the wing is pale like the middle of the wing. Hind wing with no pink band above or beneath, though the costal edge is pink. It is of the usual size, though slightly larger than one of my males of the normal form. This mountain form is apparently intermediate between Grote's race *alba* and the normal *rubicunda*.

*Egg.*—Length, 1.4 mm; oval, a little flattened; the shell yellow, thin, parchment-like, the surface smooth, polished, under a one-half inch objective showing no traces of pits or polygonal areas. The shell is so thin that unfertilized eggs collapse irregularly.

According to Riley the eggs are deposited in patches of thirty and upward on the under side of a leaf. They are pale greenish in hue.

*Larva. Stage I.*—Length, 5 mm.; at end of the stage, 7 mm. The head is deep black, large, rounded, and directly after hatching, before the larva has begun to eat, much wider than the body. Prothoracic segment at first much wider than the rest of the body and without any dark pigment on the cervical shield. The body is now pale yellowish, with a slight greenish tinge. Except a slight dusky medio-dorsal line the body is not yet striped, and there is no trace of reddish pigment on the under side.

The two horns on the second thoracic segment are about as long as the segment bearing them is thick; they are entirely smooth, with no trace of spinules; they have numerous fine wrinkles; greenish-yellow at base, beyond, black; they are slightly enlarged at the end, which is slightly divided, each fork giving rise to a seta nearly as long as the entire spine. (Pl. LII, fig. 4.)

The spines on the rest of the body (there being none on the prothoracic segment) are minute, smaller than in the other species, and much smaller than in the next stage, but with a propor-

tionably longer seta. There are two separate minute dorsal seta on the ninth abdominal segment, but they are much nearer together than the homologous ones on the eighth segment and arise from a common slightly marked low eminence.

The suranal plate (Pl. LIII, fig. 2) is concolorous with the rest of the body, not pigmented in the middle; the surface is smooth, with no conical spines, the four seta on each side not arising from definite tubercles, though there are two terminal, very small, microscopic, setiferous tubercles. At the end of this stage the larva is green, and traces of the seven lines appear.

*Stage II.*—Length, 9–10 mm. The head is now smaller in proportion than before, but still black. Prothoracic shield black. In some of the larvae it is divided in the middle by a light line. The two horns (fig. 4) are now shorter than before in proportion to the body, being about as long as the body is thick, and about two-thirds as long as the body is broad. They are now spinulated, about a dozen spinules in sight from one side. The tip is more decidedly forked than in stage I, and the setae are short—about half as long as the spine is thick. All the primary spines on the other segments are now much larger than before; stout, conical, of nearly uniform size, those of the prothoracic segments being of the same size as those behind the succeeding segment. There are three rows of spines on each side of the body, and the dorsal ones are no larger than those of the subdorsal and subspiracular series. On the eighth abdominal segment there are two widely separate dorsal spines, and two shorter ones on the ninth segment, with the median one now chitinized, black, and as large as that on the eighth segment, but a little more obtuse, with two fine setae, showing the original double nature of this spine. On the first thoracic segment, which is slightly narrower than the second, are two rounded black flattened conical tubercles, not piliferous, and two smaller flatter ones behind. Two larger subtriangular subdorsal black tubercles give rise to three minute short hairs. They are represented on the third thoracic segment by two minute conical, black tubercles, the homologous ones on the abdominal segments being minute and greenish, tipped with black. Those on the sides of each segment are larger, acutely conical and black. On the eighth abdominal segment are four conical black tubercles, two dorsal and two subdorsal, one on each side. On the ninth segment is a single median conical tubercle, not quite so high as those on the eighth segment, but larger at the base. The subdorsal tubercles on this segment are slightly larger than those on the eighth segment. Suranal plate with the terminal spine very much larger than in stage I; black, chitinized; and on each side, near the middle, is a stout, short, conical black spine. On surface and sides are a few well marked but small setiferous tubercles not visible in stage I. The suranal plate is subordinate, being excavated in front; behind it is subtriangular, with two black tubercles at the end, which are smaller than those on the side in front of the middle; the suranal plate is greenish, like the prothoracic segment, while the body is tinged with yellowish, with eight faint rather broad whitish longitudinal stripes. Along the underside of the body is a band, which varies from light lemon-yellow to reddish, and is usually darker on the underside of abdominal segments 8 and 9. The spiracles are black. The thoracic legs are black. The anal legs are greenish, with a blackish patch on the outside near the planta.

In this and the next stage it continues to feed on the underside of the leaf. Directly after shedding the skin the head and horns are pale yellowish brown.

At the end of this stage the body is somewhat reddish above, as well as beneath, while the longitudinal stripes are reddish.

*Stage III.*—Length, 12–14 mm., at end of the stage, 21 mm. The head is now chestnut red to pale sienna brown; width, 2 mm. In this stage first appear two square black patches on the prothoracic plate, and a trapezoidal patch on the suranal plate.

The two horns (Pl. LII, fig. 4) are now longer and slenderer than before, tapering rather more, and with more setiferous spinules. On the top of the prothoracic segment are two square black spots, in some cases there are four, extending back from each spine; a narrow one on each side of the two square middle ones, while the two middle ones may be divided, making six in all, or all may be wanting. The four prothoracic spines are now more developed, forming low conical warts. The dorsal spines on the last thoracic and first seven abdominal segments are

now much more prominent, longer, acute, especially those of the infraspiracular series, those on the back of abdominal segments 8 and 9 (fig. 4b) and those on each side of the suranal plate, including the terminal ones. The two middle ones on the eighth segment are the longest, being about three times as long as thick at the base, and nearly three times as long as the median one on the ninth segment, while that on each side of the median spine is as large and long as those on the side of the eighth segment. On the base of the suranal plate is a trapezoidal black patch.

The body is yellowish green, with faint darker green longitudinal stripes.

*Stage IV.*—Length, 15–25 mm. Differing but slightly from the previous stage. Width of head,  $\frac{2}{3}$  mm. Prothoracic spines flatter, a little more button-like. The horns (Pl. LII, fig. 4, 4c) are somewhat stouter than before; early in the stage about as long as the prothoracic segment is wide, but at the end not more than half as long as the body is broad. The markings are as in stage III, as also the granulations. The white stripes alternate with the dark-green ones, which are quite distinct, the black spines being situated partly on them. The black plates on the end of the midabdominal legs are well marked.

*Stage V and last.*—Length, 43 mm.; width of head,  $3\frac{1}{4}$  mm. The four prothoracic spines are flattened, smooth on top, and the four black patches are wanting. The head is cherry-red brown. The dorsal spines on all the segments (third thoracic and 1–7 abdominal), except the second thoracic (Pl. LII, fig. 4d), are not so high as broad and shorter than those of the infraspiracular series; but those on segments 8 and 9 are over twice as long as thick at base; the two median spines on the eighth segment are longer than the subdorsal one is shorter than those on the side. The suranal plate (Pl. LIII, fig. 2e), is comparatively smooth above, with four black stout spines on each side and no dark discoloration near the base.

The granulations on the skin of the body are coarser than in the earlier stages. Spiracles black.

This only differs in coloration from the previous stage in wanting the dark patches on the first thoracic segment, and the dark spot on the suranal plate, while the green lines are a little fainter; but the short lateral red stripes on abdominal segments 7–9 are as distinct.

At the end of the stage when beginning to shorten preparatory to pupation some examples are greener, the yellow being whiter and the green greener (Joutel).

The fully fed caterpillar of this species may be distinguished by its pale-green body tinged with whitish, and the seven darker green longitudinal stripes, while on the side of abdominal segments 7–9 is a broad conspicuous cherry-red line situated below the spiracles, though owing to the flattening of the body in these segments (a feature peculiar to this species) it can be seen from above. The head is cherry-red, while the spines behind the horns are smaller than in the other species of the genus inhabiting the United States. It is more nearly allied to the larva of *A. senatoria* than any of the other species.

It differs, however, from *A. senatoria* in coloration and the armature, besides being a smaller larva. The four prothoracic dorsal spines are larger and better defined, those of *A. senatoria* being nearly obsolete. The horns are a little more primitive, being slightly divided at the tip, while those of *A. senatoria* are somewhat bulbous at the end. The spines of the segments behind the horns to the 7th abdominal are slightly smaller and less stout, though of about the same length; those of abdominal segments 8 and 9 are considerably slenderer, though scarcely shorter than *A. senatoria*. The lateral spines are slenderer than in the species mentioned, where they are decidedly stouter and more prominent. The anal legs are less coarsely spined than in *A. senatoria*.

The larvae of these two species are closely allied, and judging by them the two species probably had a common origin, and since *A. senatoria* has larger, stouter spines, especially on the end of the body, this species may be regarded as the more primitive one, judging by the freshly hatched larva.

Compared with the two other species, *A. virginensis* and *A. stigma*, which are also closely allied, *A. rubicunda* and *A. senatoria* have a smaller head but stouter horns. The prothoracic spines are nearly alike in all the species, but in *A. rubicunda* and *A. senatoria* the dorsal spines

show a tendency to reduction, being much shorter especially those on abdominal segments 8 and 9. The same tendency to atrophy is seen in the armature of the suranal plate, which has smaller, less numerous spines on the upper surface, though the lateral spines are no smaller and are more pigmented. The anal legs are nearly the same in all the species.

*Pupa.*—The characters are identical with those of the other species; indeed there seem to be no distinctly marked specific characters in the pupa of this genus, either in the shape of the body, the cremaster, or the armature. Length, 3, 24 mm.

*Food plant.*—Maples of different species, especially the swamp or red maple; in rare cases the oak.

*Habits.*—This species is usually northward much less gregarious than any of the others, living after the first molt singly on the leaves of its food tree.

Although in the Eastern States this insect, especially the moth, is not common, yet we have observed it as far east as Brunswick, Me., where it feeds on the maple, the moth there appearing the middle of June; in the Western States, Illinois, Missouri, and Kansas, it proves during certain years very destructive, entirely or nearly stripping the soft or swamp, and sometimes the silver, maple of its leaves, and discouraging people from planting this tree along roadsides. It is known to feed on the oak. In Missouri and Kansas the worm is double-brooded, the first brood of larvae appearing mostly during June and giving forth the moths late in July, while the second brood of worms appears in August and September, wintering in the chrysalis state, and not appearing as moths until the following May. The caterpillar molts four times, becoming fully fed within a month, and then entering the ground to pupate.

*Parasites.*—A Tachina parasite, *Tachina (Belrosia) bifasciata* Fabr., and an ichneumon fly prey upon the caterpillars, and thus reduce their numbers. (Riley.)

*Geographical range.*—Franconia, N. H. (Mrs. Slosson); Brunswick, Me. (Packard); New York City (Joutel); Plattsburg, N. Y. (Hudson); Pennsylvania (Streeker); New Jersey, "common throughout the State, sometimes quite injurious to the maple" (Smith); Columbus, Ohio (Tallant); Missouri, Franklin County; Independence, Kans. (Riley). (See Map VI.)

In 1890 it stripped to some extent the foliage of maples at Roxie, Miss. (G. H. Kent).

This species extends farther north than any of the others. Mr. W. McIntosh writes me that it is rare about St. John, New Brunswick, but common at Amherst, Nova Scotia, and also at McAdam Station and Brownville Junction, Me. It is more common in Kansas than any of the other species.

#### ANISOTA SUPREMA H. Edw.

PL. XIX, figs. 7, 7a.

*Anisota suprema* H. Edw., Papilio, IV, p. 16, Jan., 1884.—*SCHAUS*, Papilio, IV, p. 102, May, 1884. Larva.—*DRUCE*, Biologia Centr., Lep. Het. II, p. 415, Sept., 1897.

#### Larva.

*Schaus*, W., Papilio, IV, p. 102, May, 1884.

*Imago.*—1 ♂, 1 ♀. Antennae pectinated as in *A. bicolor*. Thorax clothed with velvety dark bay, chestnut brown scales; abdomen black, at the tip reddish chestnut. Fore wings uniformly dark bay or chestnut brown; a basal line which is narrow, faint, more pronounced on the veins; an extradiscal line situated as usual, heavier than the basal and black brown. Discal spot quite large, round, more oval in the ♀ than in ♂.

Hind wings of ♂ distinctly triangular, much more so than in *A. bicolor* or *hellwigrodtii* and *A. stigma*; it is intermediate in this respect between these forms and the ♂ of *A. senatoria* and *A. virginianensis*; the ♂ is more aberrant, both in the shape of the wings and the coloration, the hind wings being reddish-pink, the veins blackish, the single transverse line broad and diffuse, blackish; in the ♀ the hind wings are black, while the ♀ fore wings are much paler than in ♂, with the basal line obsolete.

Abdomen dark brown, with ocherous rings, and the tip dull ocherous. Under side of the fore wings darker on the outer and inner edges, while the hind wings are black. In ♀ both wings are like the hind wings above; discal spot very faint.

Expanse of fore wings, ♂, 55 mm.; ♀, 64 mm. Length of one fore wing, ♂, 27 mm.; ♀, 32 mm. Breadth of one fore wing, ♂, 12.5 mm.; ♀, 16 mm. Length of hind wing, ♂, 16 mm.; ♀, 20 mm. Breadth of hind wing, ♂, 14 mm.; ♀, 15 mm.

*Geographical distribution.*—Jalapa, Mexico (Edwards); State of Vera Cruz (Schaus). Described from Edwards's type in American Mus. Nat. History.

*ANISOTA DISSIMILIS* (Boisduval).

*Aethocampa dissimilis* Boisduval, Annales Soc. Ent. Belgique XV, p. 93. 1872.

*Dryocampa dissimilis* Druce, Biol. Centr.-Amer. Lep. Het. I, p. 170; No. 1, tab. 15, figs. 9, 10. 1886.—KIRBY, Syn. Cat. Lep. Het., p. 740. 1892.

*Male.*—Boisduval describes the male as of the size of *A. anthonilis*; the fore wings of a clear reddish brown with blackish veins; extradiscal line oblique, black, preceded on the discal cell by a large white dot. The hind wings are entirely black. The thorax reddish yellow; the abdomen black above, with an anal brush of yellow hairs. The wings beneath reddish, paler at the outer edge, with the veins and a common line black. It is also figured by Druce in the *Biologia Centrali-Americanica*.

1 ♀. Head small, not prominent. Antennae filiform, slender, as usual, and much as in *A. stigma*. Head, thorax, and base of abdomen uniformly deep ochre.

Fore wings uniformly pinkish red, almost purplish brick red, with no dark specks. No basal line; extradiscal line dusky, grayish externally, not sinuous, but straight, oblique in its course, ending on the costa at some distance from the apex. A rather large distinct white discal spot. Veins dark brown.

Hind wings produced toward the apex, outer edge convex, the wings dusky, veins dark brown; fringe dark, no discal spot, but the extradiscal line is broad, blackish, and diffuse.

Under side of fore wings as above, but a little paler and the veins are darker and wider. No discal spots on wings of either pair. Extradiscal line alike on both wings, heavy, broad, black brown, and quite distinct.

Abdomen black brown except at base and at tip, which is ochreous, and the hinder edges of the dark segments are narrowly edged with ochreous. Legs and under side of abdomen black brown.

Expanse of fore wings, ♀, 73 mm.; length of one fore wing, ♀, 36 mm.; breadth of one fore wing, ♀, 49 mm.; length of hind wing, ♀, 25 mm.; breadth of hind wing, ♀, 17 mm.

In shape this species is near *A. rubricunda* and *A. stigma*, the fore wings being the same, but the hind wings are a little more produced toward the apex. In venation it approaches *Eacles* more than any other species examined (Pl. LVII, fig. 5).

In coloration this species widely diverges from any of the more northern or Austral and Appalachian forms, showing much darker tints, and thus a different facies, probably the effects of its tropical surroundings.

*Geographical distribution.*—Jalapa, Mexico (O. T. Barrett); Oaxaca (Boisduval); Oaxaca, Jalapa (Höge); common at Jalapa (Druce).

*EACLES* Hübner.

(Pls. IX, XLVIII, etc.)

*Ceracampa* KIRBY and SPENCE (in part), Intr. to Ent., III, p. 251, 255. 1828.

*Eacles* HÜBNER, Verzeichniss Schmett., p. 433. 1818-1822.

*Ceratocampa* HARRIS, Cat. Ins. Mass., Appendix to Hitchcock's Rep. Geology Mass., p. 592. 1834; Report Inv. Ins. Mass., p. 287. 1841.

*Ceratocampa* WESTWOOD, edit. Drury, Ill. Exot. Ent., I, p. 17. 1837.

*Dorycampa* DUSON (in part), Naturalist's Libr., p. 161. 1841.

*Eacles* WALKER (in part), Cat. Lep. Br. Mus., VI, p. 1370. 1855.—PACKARD, Proc. Ent. Soc. Phil., III, p. 381. 1864.—GROTE, List Lep. N. Amer., I, p. xiii. Sept., 1868; New Check List N. Amer. Moths, p. 20. May, 1882.

*Basiloma* BOISDUVAL, Annales Soc. Ent. France (4), VIII, p. 317. 1868.

*Ceratocampa* (*Basiloma*) BURMEISTER, Descr. phys. Rép. Argentine, Lép. atlas, p. 46. 1879.

- Eacles* and *Citheronia* DRUCE, Biologia Centr. Amer. Lep. Het., I, p. 169. 1886.  
*Creonidia* BURMEISTER, I, c., p. 46. 1879.  
*Citheronia* KIRBY, Syst. Cat. Lep. Het., I, p. 742. 1892.  
*Basimola* NEUMÖGEN and DYAR, Journ. N. York Ent. Soc., II, p. 151. Dec., 1894.  
*Eacles* BEUTENMÜLLER, Bull. Amer. Mus. N. Y., X, p. 442. 1898.  
*Basimola* DYAR, List N. A. Lepidoptera, p. 76. 1902.

*Imago.*—The head and shape of the front (undenuled) as in *Citheronia*. The front when denuded (Pl. XXXVI, fig. 4) distinctly triangular, widening toward the vertex; eyes large and full. Antennae pectinated to the outer third, more widely bipectinated, and with a much larger number (25) of double pairs of pectinations than in *Citheronia* (18); in ♀ simple, with minute vestigial pectinations, not so long and distinct as in *Citheronia*. Palpi very small and short, difficult to see, not reaching the front; when denuded seen to be without a third joint, the second being

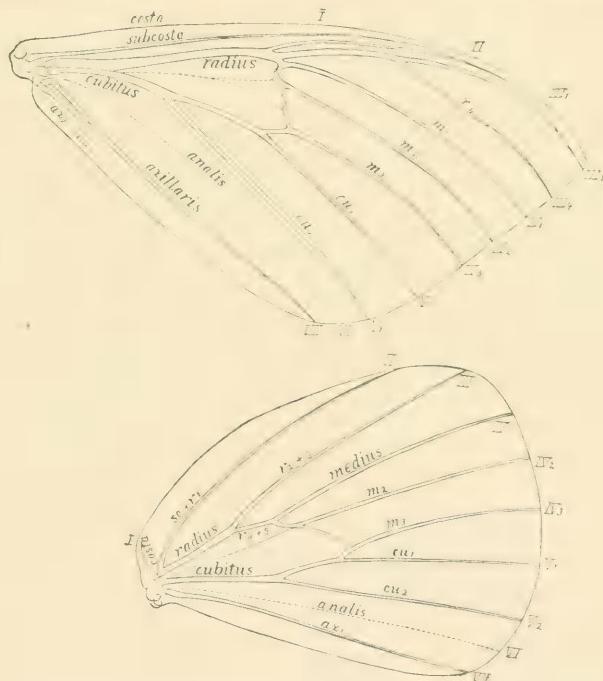


FIG. 14. Nomenclature and numbering of the veins of the fore and hind wings of *Eacles imperialis*.

obtuse at the end and a little longer than the basal one (fig. 11). Maxilla when unrolled nearly as long as the front of the head is wide (fig. 4), very slender and longer than in *Citheronia*. Thorax and abdomen stout, sphingiform.

Fore wings wide, the costal edge more arched toward the apex, which is squarish, subacute; outer edge less oblique than in *Citheronia*, much shorter than the inner edge. Hind wings more rounded, the outer edge very full and rounded, and the wings extend to the end of the abdomen. In the ♀ the wings are broader, those of the hinder pair extending beyond the end of the abdomen.

Venation (fig. 14): Vein  $III_2$  (second subcostal) wanting, while in Citheronia it is present; Vein  $IV_1$  does not arise as in Citheronia part way, usually about halfway, between the anterior discal vein and the origin of  $III_2$ , but at the outer end of the discal cell, directly in front of the discal

vein. The discal veins are very oblique, where they are straight in Citheronia; in the hind wings the obliquity of the discal cells and elongated shape of the discal cell are more marked than in Citheronia.

Fore legs with the tibia thicker, wider than in Citheronia; the tibial epiphysis being very wide (figs. 21, 21a), more so than in Citheronia.

Coloration: Body and wings yellow; wings with pale lilac blotches and spots; more or less definite discal spots and extradiscal line.

*Larva*.—Body armed with short, stout spinose dorsal horns on second and third thoracic

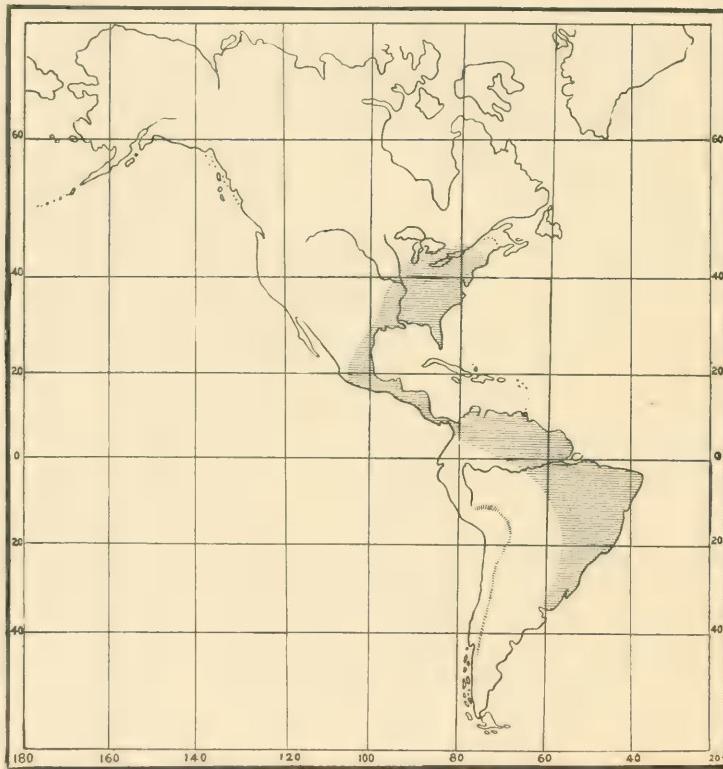


FIG. 15. Distribution of the genus *Eacles*.

segments, but none on the prothoracic segment; caudal horn very short; a vestigial median spine on ninth abdominal segment. Body with long hairs. No bands or stripes.

*Larva*.—*Stage I.*—Body armed with two dorsal branching prothoracic spines one-half as long as those of the dorsal series of the two thoracic segments behind; they are deeply forked, not ending in a bulbous expansion. Body transversely banded. A high caudal horn, and one half as high on the ninth segment; and a 5-headed spine on each side of the suranal plate. The horns become spinose after the first molt, the body being clothed with hairs after the third molt.

*Pupa*.—Body thick; maxillæ long, over three times as long in proportion as in *Adeloccephala* and *Anisota*; cremaster stouter and a little shorter, and the spines over the body smaller in proportion than in the two genera named.

*Synonymical history.*—Although Druce places the species of Citheronia under Eacles, and Kirby lumps them under Citheronia, the two genera are both in their larval, pupal, and adult characters quite distinct, as may be seen by reference to our descriptions and figures, giving structural details. The palpi have but two joints, the antennae are more broadly pectinated.

Hübner's type of the genus, i. e., the species first named, is *E. imperialis*; he then adds two other species. Basilona of Boisduval is a synonym of Eacles, and the name need not have been resurrected.

*Geographical distribution.*—Aretogæic (North American) and Neogæa; the species ranging along the Atlantic coast region from Maine and Canada, and the valley of the Mississippi, to southern Brazil.

#### EACLES IMPERIALIS (Drury).

(Pl. XVIII, fig. 5.)

*Phalaena (Attacus) imperialis* DRURY, Illustr. Exot. Ent., I, p. 17 (App. II), pl. 9, figs. 1, 2. 1770.

*Bombyx imperialis* FABRICIUS, Species Ins., II, 181, 62, 1781; Mant. Ins., II, 116, 79. 1787. Ent. Syst., III, I, p. 435, No. 89. 1793.—GMELIN, Edit. Linn. Syst. Nat., I, 5, 2417, 510.—STOLL, Suppl. Cramer, p. 178, Tab. 42, fig. 1. 1790.

*Phalaena imperatoria* ABBOT and SMITH, Lep. Ins. Georgia, p. 109, Tab. 55. 1797.

*Bombyx didyma* BEAUVOIS, Ins. Africa Amér., p. 52, Tab. 20. 1805.

*Eacles imperatoria* HÜBNER, Verzeichniss Schmett., p. 153. 1818–1822.

*Ceratocampa imperialis*, HARRIS, Cat. Ins. Mass., Appendix to Hitchcock's Geology Mass., p. 592. 1834. Second edit. 1855.—WESTWOOD, Edit. Drury III. Exot. Ent., I, p. 17, pl. 9, fig. 1, 2. 1837.—HARRIS, Rep. Inj. Ins. Mass., p. 287. 1841. Third edit., fig. 196, 197. 1862.—DUNCAN, Naturalists' Libr., XXXII, p. 161, pl. 17, fig. 1. 1841.

*Eacles imperialis* WALKER, Cat. Lep. Het. Brit. Mus., VI, p. 1371. 1855.—PACKARD, Proc. Ent. Soc. Phil., III, p. 381. Nov., 1864.

*Basilona imperialis* BOISDUVAL, Annales Soc. Ent. France (4), VIII, p. 318. 1868.

*Eacles imperialis* GROTE, List Lep. N. Amer., I, p. xiii. Sept., 1868; New Check List N. Amer. Moths, p. 20. May, 1882.

*Ceratocampa (Basilona) imperialis* BURMEISTER, Descr. phys. Rép. Argentine, V, p. 489. 1878; Atlas p. 46, Pl. xx, fig. 2. 1879.

*Eacles imperialis* DRUCE, Biol. Centr. Amer. Lep. Het., II, p. 412. Sept., 1897.  
var. *punctatissima* NEUMÖGEN, Ent. News, II, p. 150. 1891.

var. *nobilis*, NEUMÖGEN, I, c., p. 150. 1891.

*Basilona imperialis* NEUMÖGEN and DYAR, Journ. N. Y. Ent. Soc., II, p. 151. Dec., 1894.

*Eacles imperialis* BEUTENMÜLLER, Bull. Amer. Mus. N. H., X, p. 442. 1898.

*Basilona imperialis* DYAR, List. N. Amer. Lep., p. 76. 1902.

#### Larva.

(Pls. IX, XXVII, XXVIII.)

Abbot and Smith, Lep. Ins. Georgia, p. 709, Tab. 55. 1797.

Harris, Treatise Inj. Ins. Mass., third edit., p. 403, fig. 197. 1862.

Lintner, 24th Rep. N. Y. State Cab. Nat. Hist., p. 150. 1870.

Packard, Proc. Amer. Philos. Soc., XXXI, p. 157, all stages, pl. vi. 1893.

Felt, 7th Rep. Forest, etc., Comm. N. Y., pl. 13, fig. 1. 1903.

*Imago*.—3 ♂ 2 ♀. Head and thorax in front yellow. Body behind and wings bright yellow, marked with pale lilac. Disk of thorax and at insertion of the wings pale lilac.

Fore wings yellow, with distinct basal and extrabasal pale lilac lines. In two ♂ the space between the basal line and insertion of the wing is filled in with lilac, but in the ♀ it is clear; the line is broad and deeply zigzag. Two round spots near the middle of the wing, one discal, the other smaller and situated between the discal spot and the costa; each with the center paler. Extradiscal line broad, distinct, scalloped on the inner edge, slightly incurved, beginning on the outer third of the inner edge of the wing and ending on the apex; in some males the space between this line and the outer edge of the wing is more or less filled in with pale lilac.

Hind wings like the fore wings in color, distinctly speckled with round or elongated dots and strigæ; base of wing either clear, so that the broad basal zigzag line is distinct, or the line

and all within makes a lilac patch. A single discal spot, paler at the center; the extradiscal line passes very near it; it is closely wrinkled or zigzag. The outer edge of the wing is clear in all the specimens.

Under side of the wings all yellow; clearer than above, and either no lines or only faint traces of the extradiscal on the fore wings; the other being reduced and small. A triangular lilac patch on the margin.

There is a great disparity in size, though not in markings between the two sexes, and in markings it presents considerable variation. In size the Mexican female, reared in Providence, R. I., from a pupa which I collected at Cordova, Mexico, in the "Tierra Caliente," exceeded any United States specimen seen by me.

Expanse of the fore wings, ♂ 90–110 mm.; ♀ 155 mm. Length of a single fore wing, ♂ 40–52 mm.; ♀ 75 mm. Breadth of a single fore wing, ♂ 21–30 mm.; ♀ 38 mm. Length of a hind wing, ♂ 28–35 mm.; ♀ 50 mm. Breadth of a hind wing, ♂ 22–27 mm.; ♀ 38 mm.

The eggs were received from Mr. James Angus, and the larvae hatched from them reared in Maine, so that their development, owing to the cooler climate, may have been less rapid than in New York, where the eggs were laid.

*Egg.*—Length, 3 mm.; breadth, 2.6 mm.; thickness, 2 mm. Flattened elliptical, each end alike, white, with an equatorial, smooth, distinct ridge. The shell is white, the surface under a high-power triplet is seen to be finely pitted, the pits being shallow and not closely crowded. Under a half-inch objective the pits are seen to be shallow, and not often with a definite raised edge; often there is a boss or bead in the center. Arising from the spaces between the bosses are slender, short, very minute hairs, originating from a swollen base. Under a one-fifth objective, as well as a one-half and a triplet, I can not distinguish between the microscopic structure and markings of the eggs of *imperialis* and *regalis*.

*The freshly hatched larva.*—Some were seen drawing themselves out of the shell June 30 at noon. Length in a few minutes after hatching, 7–8 mm.; width of head, 1.5 mm. The tubercles and spines become erect before the larva entirely deserts the shell.

The head is large and full, smooth, shining nearly twice as wide as the body behind the middle, but the prothoracic segment is much wider than the body; the prothoracic segment is above of the same color as, and the surface shines like the head. The body is pale chestnut, with a slight pinkish tint. All the spines are, before it entirely leaves the egg, shining jet-black; the five longest ones (four thoracic and one median abdominal) bearing white hairs, the end hairs on all the shorter ones being black." The thoracic segments are without transverse dark stripes, but on each of abdominal segments 1–7 there are three transverse, distinct, conspicuous, black dorsal stripes; the first one in the front of the spines is broken, and wanting on the first abdominal segment, but the two behind are unbroken and extend a little below the position of the spiracles. The spiracles are hard to detect, as they are situated on an oblong or fourth transverse black band between the two lateral spiracles. The eighth and last two segments are not banded. The large anal legs are edged with black behind. The thoracic legs are black.

There are four spines on each side of the prothoracic segment, all of very unequal length; the lowest one minute and bifid; the one in front of the spiracle stumpy and ending in five slender, papilliform, piliferous tubercles. The subdorsal one is much longer and forked, while the two dorsal ones are very long and slender, about as long as the head is broad and deeply forked, each fork bearing a bristle. *The two dorsal tubercles on the second and third thoracic segments are*

"I am always amazed at the difference in experiences. This morning I watched a set of *E. imperialis* hatch, and in every instance the sets of the tubercles were white for several minutes after the larva had left the egg, except those of the four tubercles over the head, which were black before hatching, and could be seen through the shell clearly.

"The rapid growth of the long "horns," after leaving the shell, was most interesting. In five minutes they were of normal size, but half an hour was needed to give them the shining black color; in some cases longer.

"After watching them I looked up this point in your pamphlet on *Creatocampidae*, and saw how your experience differed. Then I went back to my remaining eggs and watched the process from the moment the egg was broken, hoping to find some agreeing with yours, but none would. I had a 15-diameter magnifier, and could see clearly."—Miss Caroline G. Soule in a letter.

enormously long and very slender, being about half as long as the body. They are deeply forked, each fork long and slender, and bearing a long bristle. The tubercles on abdominal segments 1-7 are small and short, of nearly equal length, simple except those of the infraspiracular row, which are deeply forked. The single median tubercle on the eighth abdominal segment is remarkably long and slender, about two-thirds as long as the thoracic ones. *There is also a single median forked tubercle on the ninth segment; not half as long, however, as the one directly in front.* The suranal plate bears at the end two long five-branched piliferous tubercles. All the tubercles are of nearly the same color as the body; the five longest ones, however, a little brownish near and at the end.

The four middle pairs of abdominal legs are shining black externally on the outer half; otherwise they are concolorous with the body.

The following description is drawn up from some larva at the end of stage I, living October 9 or 10 and reared by Mr. Bridgman; they were about 7 mm. in length, and had been kept for a number of days, and died before molting. The head is large, full and rounded, smooth and shining honey-yellow; nearly twice as wide as the body (actual width, 1.5 mm.), rounded above on the apex; the eyes and mouth parts black; labrum whitish. The body is ocherous. The prothoracic segment is very broad and flaring in front, nearly as wide as the head, bearing ten black spines, of which the two dorsal ones are about as long as the body is thick, each bearing three or four small, short tubercles, and ending in a long fork, each branch bearing a long seta, which is white at the base. The subdorsal spines are a little less than half as long and large as the dorsal ones. The dorsal second and third thoracic horns are very long and large, being nearly twice as long as the middle of the body is thick; the stalks are knotted (not tuberculated) and deeply forked at the end; each fork thick and ending in a seta. Those on the third segment are slightly shorter, with a smaller fork than the two on the second thoracic segment. Each abdominal segment is provided with six black spines; the two dorsal ones about half as long as the body is thick, with two or three minute warts; they are forked at the end, the lower fork small, about as long as the spine is thick, and not bearing a seta, while the other fork or tine is directed obliquely upward.

The spines of the next row outside (subdorsal) are small and simple, while the lateral row near the base of the legs is composed of branched spines nearly as large as the dorsal ones, and with each branch ending in a long seta. The caudal spine on the eighth abdominal segment is nearly as large as those on the second and third thoracic segments, but with a smaller fork, each ending in a seta. There is a median dorsal spine on the ninth segment, about one-half as long and large as that on the eighth, with three branches, the two terminal forming an uneven fork. There is no distinct suranal plate, only a subtriangular flattened area bearing along the edge six black spines of very unequal size. Around abdominal segments 1-7 is a double, black band, and the lateral and subdorsal spines on these segments are connected by a black band, also inclosing the spiracles, these short bands alternating with long bands passing over the body. The thoracic legs are black; the abdominal legs dull ocherous, with a large, black patch covering the outside. The anal legs are rather large and square, ocherous, the hinder edge pitchy red.

It may be observed that the median dorsal spines on the eighth and ninth abdominal segments are forked like those of *Hyperchiria io*.

*Stage II.*—July 10, 11. Length, 13-15 mm. The head is as wide as the thoracic segments (exact width, 2 mm.); it is chestnut brown, a little darker on the sides above the eyes and on the clypeal region. The spines on the prothoracic segment are much as before, *but stouter and shorter.* The dorsal spines on the second and third thoracic segments are much as before, *but not quite so deeply forked;* they are dusky amber wax at the base, and black beyond; they are irregularly spinose from base to tip; each fork bears a white hair. *All the other spines are black.* The "caudal horn" on eighth abdominal segment is stouter at base, the trunk with larger, longer, and more numerous spinules, which end in a bristle which is not present in stage I; it is still evenly forked.

The subdorsal spines are now much shorter than before and simple and conical; while the lateral series, instead of being nearly as long as the dorsal ones and deeply forked, are short and stout, ending in three short, stout, piliferous spines.

The body is now dull chestnut, with dusky discolorations, but *without the decided black bands and spots of stage I*, the body being decidedly darker. The black spiracles are surrounded by a diffuse black ring. The thoracic legs are black; the middle abdominal legs jet-black outside, on a chitinized portion; the anal legs are of the color of beeswax, with a jet-black spot or wart at the tip, and a dusky patch on the sides; these black plates are *larger and longer than in stage I*.

The descriptions of stages III and IV were drawn up from a series reared at my request by the late Mr. S. Lowell Elliott and preserved in alcohol; the colors are described from a set of drawings by Mr. Bridgman. Mr. Elliott observed five stages.

*Stage III.*—(Preserved the third day after the second molt.) Length, 30 mm.; width of the head, 3 mm. The head is narrow, about one-half as wide as the second and third thoracic segments; chestnut brown, with two pale, longitudinal bands in front, each band ending at the base of the pale antennae. *The two dorsal spines on the prothoracic segment are much shorter than in stage II*, with much stouter lateral spinules, and with shorter forks at the tip, and the spines on the trunk are shorter. The two second thoracic dorsal spines are a little stouter than before, but are nearly as in stage II, and are spinulated in the same way; they are 4.5 mm. in length; they are pale on the basal half and dark brown on the distal half; the corresponding spines on the third thoracic segment are a little shorter. *The dorsal and lateral spines on abdominal segments 1-7 are much smaller in proportion than in stage II*, the dorsal spine being still unevenly forked. The "caudal horn" on the eighth segment is now 3 mm. in length, and is still regularly forked as before. *The corresponding single median spine on the ninth segment is minute and much smaller than before*. The two larger spines on the suranal plate are *smaller than before*, each bearing four spines, and behind these on the edge of the plate are four minute conical spines; the plate is regularly rounded behind; it is dark brown in the middle, with paler rounded granulations. On the side of the anal legs is a similarly ornamented *distinct, narrow, triangular field not developed in stage II*. The middle abdominal legs are tipped with black as before. The body is more hairy than before.

The general hue of the body is at first pale yellowish brown (raw sienna), with a large pale area around the dark spiracles. There are no distinct markings. Toward the end of the stage the body in those feeding on white pine becomes decidedly reddish, and in fact the color varies from violet through all shades of golden brown and orange purple to black. The horns are rosy-red at base; there is a broad, pale, diffuse, subdorsal band on each side and the dark spiracles are rendered very conspicuous by the broad yellowish ring around them.

*Fig. 3.* Armature of *Eacles imperialis*. Stage I. *a*, a dorsal prothoracic spine; *b*, a subdorsal prothoracic spine; *c*, a dorsal spine of the second thoracic segment; *d*, a dorsal spine of the third thoracic segment; *e*, the first abdominal segment, side view, showing the anterior and posterior black band, and the position of the dorsal, subdorsal, and infraspiracular spines with the spiracle; *f*, the suranal plate, in part, bearing the anterior spine, ending in four setiferous tubercles and the two smaller, simple spines at the end of one side of the plate; *g*, the "caudal horn" or medio-dorsal forked spine of the eighth uromere, seen partly from the side; *g'*, end of the same, seen from in front, showing the two forks; *h*, one of the dorsal spines on the ninth uromere. All drawn with the camera to the same scale.

*Fig. 4.* Armature of *Eacles imperialis*. Stage II. *a*, end of one of the dorsal prothoracic "horns"; *b*, one of the dorsal second thoracic "horns"; *c*, the "caudal horn," or medio-dorsal spine on the eighth uromere. Stage III. *d*, one of the second thoracic "horns"; *e*, the "caudal horn" or medio-dorsal spine of the eighth uromere. All drawn with the camera to the same scale.

*Stage IV.*—(Four days after the third molt.) Length, 40 mm.; width of the head, 4.5 mm. The characters of the full-grown larva are now nearly assumed. The head is, in one specimen, twice banded with pale yellowish in front, in another the bands are nearly obsolete and the head

almost entirely dark chestnut. The two dorsal prothoracic tubercles are now very short, not so high as broad, and end in a group of rounded conical spinules; those on the side of the same



FIG. 16.—Armature of *Eacles imperialis*.

segment having the same general shape. The second and third thoracic segments, with the dorsal horns, now much as in the full-grown larva, though a little slenderer; length, 5 mm.; they are

more curved than before and directed backward and provided with numerous dense conical tubercles; they are pale yellowish at base, and rosy on the distal half, becoming black at the tip, which is still regularly forked; the two pairs are of the same shape and length. The abdominal dorsal spines are much stouter and shorter in proportion than in stage III. The subdorsal (supraspiracular) spines are simple, conical; the lateral (infraspiracular) spines are very short, and composed of four spines. *The "caudal spine"* (single median dorsal spine on eighth abdominal segment) *is now much stouter, more conical than before;* 2.5 mm. in length and furnished with crowded spines, but still ending in a regular fork. The suranal plate is as before, but the spines are shorter, and the exterior of the anal legs are ornamented as before.

*The hairs are now long and abundant,* some of the dorsal ones longer than the body is thick. The spiracles are very conspicuous, each being surrounded by a broad green ring, outside of which is a yellowish ring, which is margined with yellowish brown. The body is dark umber-brown; the reddish spines and the spiracles, as well as the reddish edges of the suranal plate and anal legs, decidedly contrasting with the dark hue of the body. The color of the spiracles varies in different individuals, being sometimes mostly white or green or red. Also the yellow color around it is sometimes larger and of different width, sometimes being reduced to a line.

The last stage differs from stage IV in the shorter dorsal horns and caudal horn, those on the sides also being decidedly shorter, and the anal legs are larger, with a wider dark granulated area on the sides, and the body is much thicker and heavier, while the head is pale.

*Last (fifth) stage.*—Length, 10 cent. (Described from one living on the choke cherry.) Head one-half as wide as the body; width, 7 mm.; deep gamboge-yellow, and green on the side; a double, deep-black frontal line extending from the vertex, diverging below so as to leave a median yellowish line on the upper division of the clypeus. The front division of the clypeus (clypeus anterior), the antennae, and the base of the jaws yellowish. The thoracic legs and the horns on the second and third thoracic segments and the anal legs with the suranal plate are all of the same color, i.e., deep shining gamboge-yellow. The general color of the body in the green individuals is a delicate pea-green (more usually the individuals are brown or tawney), varying from the shade of the upper side of the cherry leaf to that of the under side, being paler above along the back and especially on the sutures than on the sides. The hairs are long and slender and whitish, most of the dorsal ones as long as the body is thick. There is a prothoracic plate of the same green hue as the body, but with yellowish edges. Of the four horns on the second thoracic segment, the outer ones are half as long as the inner or dorsal ones, which are 4.5 mm. in length; those of the third thoracic segment are of the same size as those on the second. There are four similar but much smaller dorsal and subdorsal horns on each of the abdominal segments (but they are shorter and more regularly conical than in stage IV), those on each segment being of the same size, the two dorsal ones being almost three times as large as the subdorsal ones, each dorsal one bearing three terminal spines. Those on the thoracic segments are tuberculated, ending in a fork. On the eighth abdominal segment is a median dorsal horn, now shorter in proportion than in stage IV, small and short, length 2 mm., nearly twice as large as the other dorsal ones in front, tuberculated and slightly forked at the end, but not so regularly forked as in stage II. There is a minute median one on the ninth segment, and two minute lateral ones on each side of the segment. The spiracles are very large and conspicuous, yellow with an outer ring of very dark green, which is edged on each side with paler green; those on the prothoracic segment are without the deep-green outer ring. The suranal plate is regularly triangular, gamboge-yellow, with a swollen, rough, coarsely granulated edge, within which the surface is black, with yellow coarse granulations. A similar narrow triangular plate on the anal legs. The middle abdominal legs dark pea-green, with a deep ochre-yellow transverse band above the black plauta.

For a careful description of the egg and the larva in its first four stages see Dr. J. A. Lintner's Ent. Contr., II, 150. His larva molted four times, and he thought from the small size of the specimens after the fourth molt that there might be a fifth one.

The fifth and last stage differs from stage IV in the shorter dorsal horns and caudal horn;

the tubercles on the sides of the body also being decidedly shorter, while the anal legs are larger, with a wider, dark, granulated area on the outside. The body is also thicker and heavier, while the head is paler.

It is noticeable that in this form, as in the Attacinae, there is a great increase from one stage to another in the size or bulk of the body, while the head does not increase in a corresponding ratio.

#### SUMMARY OF THE CHIEF ONTOGENETIC FEATURES.

##### A.—*Congenital characters.*

1. In stage I there are three pairs of very long dorsal deeply forked thoracic horns, nearly half as long as the body.
2. A similar median spine on the eighth abdominal segment, with one about half as long on the ninth.
3. The abdominal segments are transversely banded with black.
4. The lateral spines on the abdominal segments bifid and nearly as large as the subsimple dorsal ones.
5. Body pale chestnut brown; head light reddish.
6. The spiracles minute and difficult to detect, as they are situated in one of the transverse black bands.

##### B.—*Evolution of later adaptational characters.*

1. The forks of the larger dorsal spines disappear at the end of stage III.
2. The dorsal thoracic spines become recurved in stage III.
3. The dorsal thoracic and caudal horns become much shorter and stouter in stage IV, when the characters of stage V (and last) are nearly assumed.
4. In stage II the dorsal spines on the prothoracic segment begin to grow shorter and stouter.
5. In stage II the large horns begin to be less deeply forked.
6. The transverse black stripes disappear at the end of stage II.
7. The dorsal and lateral spines on abdominal segments 1-7 are much smaller in proportion in stage III than in stage II.
8. Toward the end of stage III the colors of the body become more conspicuous and variable.
9. In stage III the spiracles become particolored and very conspicuous.
10. The dorsal thoracic and the caudal horn become much shorter in stage IV, and not forked at the tip.
11. The hairs become long and abundant in stage IV.
12. The body in stage IV becomes much stouter and heavier than before, while the head has not greatly gained in size proportionally.

*Food plants.*—Oak, button wood, bass wood, maple, honey locust, wild cherry, sweet gum, sassafras, elm, sycamore, beech, chestnut elder, horn beam, birch, alder, white pine, spruce, cedar, cypress, juniper, (Beutennüller). Sometimes injurious to trees, in Central Park, New York (E. B. Southwick).

*Habits.*—The transformations of this moth were first described by Harris, but the earlier stages were first fully described by Mr. Lintner in his Entomological Contributions No. II. Though usually feeding on the white pine in the New England States, where we have seen it in the breeding cages of entomological friends, it also feeds on the oak, button-wood, etc., and will eat the leaves of the chestnut. It is too rare to be of any economical importance, but will always attract the attention of lovers of fine, rather rare insects. The moth lays its eggs in the northern States late in June, hatching in about a week or ten days; the larva, according to Lintner, molting at least four if not five times. A local name for it in Rhode Island is "custard moth."

I have found the pupa at Cordova, Mexico, in March, buried in the earth.

*Varieties:* Mr. Doll has kindly shown me a variety of the larva from Brandt Lake, in the Adirondacks, in which the body is green. The Adirondacks larva has longer, more prominent

spines than Brooklyn specimens, and they are white and conspicuous. In the penultimate stage, with a length of 35 mm., the spines are also a little longer and slenderer than in normal *E. imperialis* of the same stage. It might be added that normal *E. imperialis* larva vary in the size of the spines of the infraspinaular series; in one example they are nearly obsolete, and in another they are well developed. It is well figured by Mr. Joutel on Plate XV.

Beutennüller states that var. *punctatissima* is an aberration probably produced by cold.

In the Neumoegen collection of the museum of the Brooklyn Institute there is an Eacles from the City of Mexico which differs from *E. imperialis* in the extradiscal line of the fore wings being near the outer edge, the line being perfectly straight and firm, not scalloped. Both wings are suffused with reddish brown, and the outer edge of the wings of both pairs partly reddish, not lilac red as in *E. imperialis*; the costa is straight and the apex acute. Expanse of fore wings, 112 mm. It may prove to be a form or local variety of *E. imperialis*, and seems to resemble Schaus's *E. masoni*.

*Geographical distribution.*—It has not yet been found north of Massachusetts and southern New Hampshire; Claremont, N. H. (F. H. Foster); Cambridge, Mass. (Harris); Providence, R. I. (H. L. Clark, J. Bridgham, Deardon); Plattsburg, N. Y. (Hudson); Ithaca, N. Y. (Slingerland); New York City (Joutel); Pennsylvania (Strecke); New Jersey, "usually common throughout the State," Newark in July (Smith); Columbus, Ohio (Tallant); Springfield, Alton, Ill. (Riley); St. Louis, Mo. (Riley); Cordova, Mexico (Packard); Jalapa (Druce). Race *nobilis*, Texas (Neumoegen).

*Pupa.*—♂ and ♀. (Pl. LVI, figs. 5, 5a.) Body much thicker than in Adelocephala and Anisota, but the head and thoracic region less full and rounded; the abdominal sutures also less deeply impressed.

The little spines on the vertex and front of the head are smaller and farther apart than in Adelocephala and Anisota. The ♂ antenna are wider beyond the middle, i. e., on their distal half, than in the two genera named. The maxillae form a triangular space nearly four times as long as broad, while in the two above-mentioned genera they form together a nearly equilateral triangle. The ♂ cremaster is stouter, a little shorter, and less deeply forked than in Adelocephala and Anisota, while the end of the body is much smoother and less coarsely punctured. The ♀ cremaster is a little stouter, with much coarser granulations or bosses, and the spines near the base are longer than in the ♂.

There is a group of 6-8 spines on each side of the prothoracic tergum, behind the insertion of the antennae, which are not present in the two other genera mentioned in which a group of such spines arise from the vertex of the head itself between the base of the antennae. The hind edge of the antenna spinose, but the spines are shorter than in Anisota; on the front edge is a series of slight, low, nearly obsolete spines.

Length of ♂, 36-40 mm.; thickness of the body, 14-15 mm. Length of ♀ (the large Mexican one), 60 mm.; thickness, 19-20 mm.

#### EACLES CACICUS (Boisduval).

*Basilona cacicus* BOISDUVAL, Annales Soc. Ent. France (4<sup>me</sup> sér.), VIII, p. 318. 1868.

*Eacles cacicus* WALKER, Cat. Lep. Het. Br. Mus., VI, p. 1375. 1855.—KIRBY, Syn. Cat. Lep. Het., I, p. 743. 1892.

*Basilona imperialis* BURMEISTER, Deser. Phys. Rép. Argentine, Atlas, p. 46, Pl. XX, fig. 2. 1879.

#### Larva.

(Pl. XVII, fig. 2.)

*Burmeister*, Pl. XX, fig. 2.

Boisduval states that this species is very near *E. imperialis*, but that the female is much larger. The fore wings of the male are much more pointed and a little falcate; the rose color is replaced by brown, which reflects violaceous tints; the ring-like spot is accompanied toward the costa by a dot of the same hue. The thorax is of the same brown as the base of the wings. The female offers more decided differences; besides its greater size it is without the brown tint at the base of the fore wings, this being replaced by a sinuous basal line.

Walker states that there is in the ♀ a slender zigzag reddish band near the outer border. Expanse of wings, 52 lines.

I had supposed that this was probably only a climatic variety of *E. imperialis*, but on an examination of the larva and pupa preserved in the Cambridge Museum, and kindly loaned me by Mr. S. Henshaw, I find that there are differences in both larva and pupa, which appear to be most probably constant. If so, then *E. cacicus* is probably the stem-form inhabiting Brazil, the probable center of origin of the genus, and our Central and North American *E. imperialis* is probably a later climatic species, its specific characters having been assumed as the result of its exposure to a cooler, more northern climate.

*Larva*.—(Pl. XVII, figs. 2, 2 A, 2 B. Copied from Burmeister.)

An alcoholic specimen differs from a blown example of *E. imperialis* from New York in its much larger size. The head is dark, as was probably the body, as in Burmeister's figure. The dark head is yellowish brown on the sides. Prothoracic shield and armature just as in *E. imperialis*; the vestigial spines low, not nearly so high as broad. The most marked difference is seen in the dorsal and subdorsal second and third thoracic horns and in the caudal horn. They are in *E. cacicus* very long and slender, and the spinules are fine and slender, acute, not coarse, thick, and short as in *E. imperialis*. The horns are also slenderer at base and not subconical as in *E. imperialis*, and are considerably longer in proportion. (See Pl. XLVIII, fig. 4.)

Another decided difference is the equality in size of the horns of the dorsal and subdorsal series (57) in *E. cacicus*; in this species those of the subdorsal series are slightly thicker, but very slightly shorter, than the dorsal ones, while in *E. imperialis* they are about a third as long and scarcely higher than broad; they bear about 12 spinules, which are not short, broad, and crowded together, as in *E. imperialis*, being on the contrary slender and delicate, very acute. The caudal horn (fig. 4, c) is also longer and higher, less curved, thick at the base, and with scattered, slender spinules.

The body is very hairy, densely so, the hairs being pale horn-colored and rather longer than in the most hairy *E. imperialis*. The suranal plate armed with granulations, which are crowded as in *E. imperialis*, but coarser and rounded. Anal leg with somewhat crowded granulations, which are larger and more rounded than in *E. imperialis*.

Burmeister states that the spines are *rouge carmine*, but those of our *E. imperialis* are always dark brown or yellow. The ground color of the body varies according to Burmeister in being of a clear green or of an obscure grayish brown. We infer, therefore, that dichromatism occurs in the South American larva as well as in its representative in North America.

The stigmata of *E. cacicus* are carmine red with a white ring (*ceinture*). The abdominal legs are marked with a large lacquered red spot above the planta.

Burmeister, stating that Boisduval gives to the North American type, which is smaller and clearer in color, the name of *imperialis*, and to the South American that of *L. cacicus*, adds that the individuals from Buenos Ayres resemble the North American form in size and color, with some apparent modifications in ornamentation, bringing it nearer the Brazilian type. "This form is known under the name of *Basiliana* (or *Cremadina*) *opaca*." (Atlas, p. 46.)

*Pupa*.—Length, 65 mm.; thickness, 20 mm. (Pl. LVI, figs. 6, 6a). It differs from that of *E. imperialis* in the longer maxillae and legs. The labrum is more distinct; the head in front less rugose, but elsewhere, namely on the wings and body, the surface is more spinose (compare figs. 5 and 6 and 5a with 6a). The hinder edges of the posterior abdominal segments are much more spinose, the teeth or spines on the hind edge of the sixth abdominal segment being longer than thick, and acute. The cremaster is smooth on the under side, whereas in the 3 of *E. imperialis* there are longitudinal ridges; on the upper side it does not specially differ from the other species named. The armature on abdominal segments 8-10 is much as in *E. imperialis*.

*Food plants*.—In Brazil, according to Burmeister, it lives on different plants; he found it at Rio de Janeiro on *Mangifera indica*, at Buenos Ayres on *Erythrina crista galli*.

*Geographical distribution*.—Rio Janeiro (Agassiz, Museum of Comp. Zoology, Cambridge, Mass.); Rio Janeiro (British Museum); Brazil (Beske in Boisduval).

## EACLES PENELOPE (Cramer).

- Athaea penelope* CRAMER, Papillons exot. I, p. 70, Pl. XLV, fig. A. 1774.  
*Eacles penelope* HÜBNER, Verzeichniss Schmett., p. 153. 1818-1822.  
*Lonomia penelope* WALKER, Cat. Lep. Het. Br. Mus. VII, p. 1766. 1856.  
*Basidoma ducalis* BOISDUVAL, Annales Soc. Ent. France (4me sér.) VIII, p. 319. 1868.  
*Eacles ducalis* WALKER, Cat. Lep. Het. Br. Mus. VI, p. 1374. 1855.  
*Eacles penelope* PETERS, Die Heterocerinen-Raupen, p. 9, larva, Tab. III, fig. 7. (1898)-1901.  
*Basidoma penelope* BURMEISTER, Descrip. Phy. Rép. Argentine, Athas, p. 46, Pl. xx, fig. 1. 1879.

Burmeister gives an excellent figure and description of the larva. (See our Pl. XVII, fig. 1.)  
 Peters describes the larva, which seems to be a true Eacles, having no spines on the prothoracic segment, but low tubercles instead, the dorsal and caudal horns being short and stout—as having a violet dorsal line bordered with white. It is peculiar in having yellow wart-like outgrowths on the anal legs and suranal plate (Afterklappe).

*Food plant.*—It lives on Melastomaceae, also on the guava (*Pisidium pomiferum*), one of the Myrtaceae.

*Geographical distribution.*—This species does not occur near Rio, and only inhabits the highlands, also occurring in the more southern states of Brazil. Cramer records it from Surinam.

The moth entirely differs from *E. imperialis* and *magnifica*, in the male sex.

## SPECIES NOT SEEN BY ME.

- Eacles ormondei* SCHAUß, Ent. Amer. V, p. 192, ♀ 1889; Journ. N. Y. Ent. Soc., IV, p. 154, ♂. 1896.—DRUCE, Biol. Centr.-Amer. Lep. Het. II, p. 413. Tab. LXIX, fig. 10, ♂. Sept., 1897.

Judging from Druce's figure this species differs from *E. imperialis* in rather slight features. The wings are of the same shape, the spots and bands in the same position. Perhaps it will be found to be a local variation of *E. imperialis*.

It occurred in Coatepec and Orizaba, Mexico (Schaus).

- Eacles masoni* SCHAUß, Journ. N. Y. Ent. Soc. IV, p. 154. Dec., 1896.—DRUCE, Biol. Centr.-Amer. Lep. Het. II, p. 413. Tab. LXIX, fig. 9, ♂. Sept., 1897.

This also appears to me, judging from Druce's figure of Mr. Schaus's type, to be a local form or variation of *E. imperialis*. The fore wings are more acute than in *E. ormondei*, but *E. imperialis* varies in this respect. The outer edge of the hind wings is dull brown and the fore wings more suffused with brown ochreous than usual. The discal spots of both wings are situated much as in *E. imperialis* and are of the same size and color. Orizaba, Mexico (Schaus).

- Eacles magnifica* DRUCE, Biol. Centr.-Amer. Lep. Het. I, p. 169. Tab. 15, fig. 13, ♂. II, p. 412. Sept., 1897.

This is truly a magnificent form, but yet I am inclined, judging only from Druce's figure, to suppose that it may prove to be but a local variety of *E. imperialis*, unless it prove to be *E. cecicus*. The shape of the wings is the same; the discal spots and lines and patches of purplish on both wings are almost identical with a smaller male from Pennsylvania.

Druce records it from Cordova, Durango City, Mexico; Chontales, Nicaragua; Joyabaj, Guatemala, and also the city of Guatemala; Volcan de Chirique, Panama; San Pedro Sula, British Honduras; Pará, Rio de Janeiro, Brazil; Argentine Republic and Paraguay.

## CITHIRONTA Hübner.

(Pls. XVIII, XIX, XX.)

- Bombyx* FABRICIUS, Ent. Syst., III (1), p. 436. 1793.  
*Phalaena* ABBOT and SMITH, Lep. Ins. Georgiæ. 1797.  
*Citheronia* (Eacles pt.) HÜBNER, Verzeichniss Schmett., p. 153. 1818-1822.  
*Ceracampa* KIRBY and SPENCE, Intr. Entomology, II, p. 235, III, p. 179. 1828.  
*Ceratocearpa* (Ceracampa Kirby) HARRIS Cat. Ins. Mass., p. 591. 1834; Ibid., Hitchcock's Rep. Geology of Mass., pp. 72, 592. 1855; Rep. Inv. Ins. Mass., p. 287. 1841; third edit., p. 399. 1862.—WESTWOOD, Edit. Drury, III, Exot. Ins.  
*Dorycearpa* (in part) DUNCAN, Nat. Libr. Exot. Moths, p. 158. 1841.  
*Eacles* (in part) WALKER, Cat. Lep. Het. Br. Mus., VI, p. 1370. 1855.

*Citheronia* PACKARD, Proc. Ent. Soc. Phil., III, p. 381, Nov. 1864.—GROTE and ROB., Proc. Ent. Soc. Phil., IV, p. 222, April. 1865; Annals Lyceum Nat. Hist. N. Y., VIII, p. 29, Pl. XII, fig. 1 ♂. 1866.  
*Ceratosanga* BOISDUVAL, Annales Soc. Ent. France (4<sup>me</sup> sér.), VIII, p. 310. 1868.—BURMEISTER, Descr. Phys. Rép. Argentine, V, Lép. p. 486. 1878.  
*Citheronia* and *Eacles* KIRBY, Syn. Cat. Lep. Het. I, p. 742. 1892.  
*Citheronia* NEUMOGEN and DYAR, Journ. N. Y. Ent. Soc. II, p. 150, Dec. 1894.—DYAR, List Lep. N. A., p. 76. 1902.

*Imago*.—Head broad in front, subtriangular when denuded; eyes large and round. Antennae of ♂ bipectinated to a little beyond the middle; the pectinations shorter, stouter, and more densely ciliated than in Eacles and less numerous (18 double pairs); in ♀ simple, but with fine, minute, vestigial pectinations, a single pair to each joint.

Palpi stout, moderately large, slightly ascending, extending slightly or well beyond (in *C. sepulcralis*) the front; the third joint distinct, button-like. Maxillæ minute, but distinct, though very short, scarcely reaching beyond the palpi. Thorax and body stout and heavy, sphingiform.

Fore wings narrow, apex prolonged, subacute; costa nearly straight to the apex, which is subacute; outer edge very oblique, as long as the inner edge. In ♀ the wings are much broader, and the apex more obtuse. Hind wings rounded at the apex, but more produced in this region than in Eacles, and the wing is more subtriangular. They do not extend so far toward the end of the abdomen as in Eacles. Legs not so stout and thick as in Eacles, and the tibial spur of the ♂ is not quite so broad; it is a little more than half as long as the tibia itself.

Venation (Pl. LVII, figs. 1, 1a): As will be seen by the figures, the venation is quite constant in the four species examined. Vein  $III_3$  is always present, and is long and well developed;  $III_1$  always arises well within the outer end of the discal cell, i. e., within the discal veins. The latter together form a less oblique line than in Eacles, and tend rather to curve in toward the cubital vein (—); the discal cell is rather small, triangular. In the hind wings the outer end of the discal cell is straighter, less oblique than in Eacles, the discal veins being in *C. luecom* (*ixion*) more oblique, and thus approaching Eacles more than the other species examined.

Coloration: Ground color, tending to be brown-orange, orange-red on the veins, with yellow spots, or lilac-brown predominates (*sepulcralis* and *mexicana*); no definite discal spots; in some species a submarginal red or yellow zigzag line.

Genitalia (Pls. LIX, fig. 8a; LX, figs. 2, 2a-2d): Suranal plate, narrow, style-like (*regalis*), or broad and triangular (*sepulcralis*); two pairs of claspers; the lower pair distinct from the upper, hook-like, curved upward, divided at the end; upper claspers, seen sidewise, large, broad, oval; from above, narrow, oval, with no terminal projection or hook. Penis, style-like.

The genital armature of the male is characterized by the broad, oval claspers, the large harpes, the short penis-guard ( $\rho^1$ ), and the long, acute penis (fig. 2b,  $\rho$ .)

*Egg*.—Flattened, oval cylindrical; shell thin, parchment like, obscurely and very minutely sculptured, with hexagonal pits. (See p. 132.)

*Larva*.—A pair of long dorsal prothoracic horns in addition to those on the second and third thoracic segments; the latter very large, usually longer than the body is thick; caudal horn long, nearly half as much so as the thoracic horns; a shorter median horn on the ninth abdominal segment. The other dorsal and lateral abdominal spines longer than in any other genus except Adelocephala; suranal plate rugose, but not granulated, differing in this respect from Eacles; bearing two short low stout spines one on each side of the middle.

Young larva, before molting, with long spinous thoracic horns ending in bulbous expansions, bearing a lateral terminal rod on each side; the caudal horn with a similar ending; the other spines long and branching, differing from Eacles in the bulbous endings and the spinulose shafts of the horns.

*Pupa*.—Body very thick, rounded in front; end of abdomen very blunt, cremaster reduced to a vestige ending in two small rounded tubercles; body smooth with no spines; maxilla long, though slightly shorter than in Eacles. It should be observed that Burmeister represents the pupa of *C. principalis* with a large, well-developed, forked cremaster. (Pl. xx, fig. 6 on Pl. XVII.)

*Geographical distribution.*—The genus is distinctively a South and Central American one, i. e., neogaeic, a single species having perhaps migrated from Brazil and the regions northward up into the Mississippi Valley and along the Atlantic coast as far north as Massachusetts, then becoming modified, and assuming its peculiar characters. A second species, *C. sepulcralis*, appears to be peculiar to the Atlantic States, ranging from Maine to Georgia, but not yet known to occur west of the Alleghanies.

*Synonymical history.*—The names *Ceracampa*, *Ceratocampa*, and *Dorycampus* were bestowed on this genus in ignorance of Hübner's work, which at the time those names were proposed was

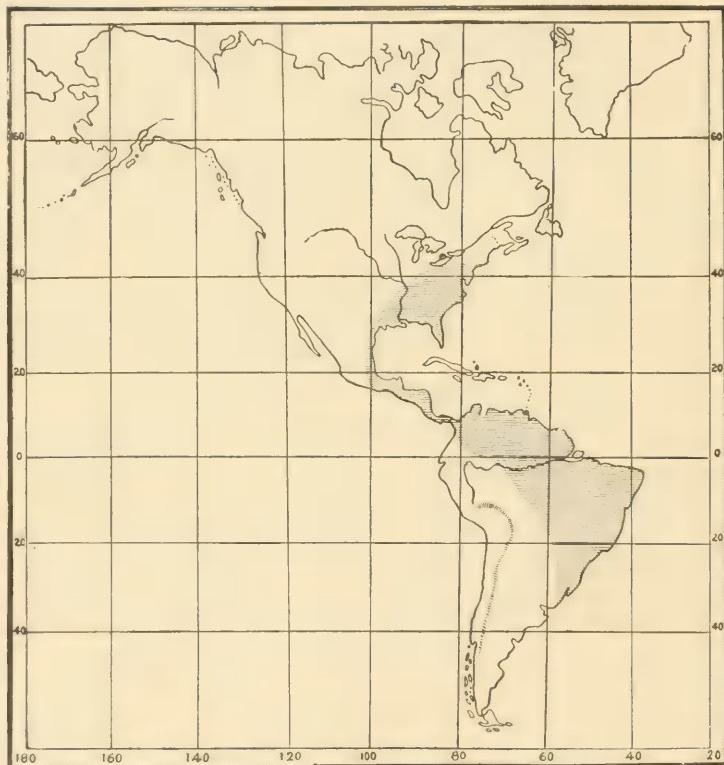


Fig. 17.—Distribution of the genus *Citheronia*.

an obscure book. The recent combination of *Eacles* and *Citheronia* by Kirby was scarcely a step in advance.

**CITHERONIA REGALIS (Fabricius).**

(Pl. XXXV, figs. 1, 1a.)

*Bombyx regalis* FABRICIUS, Edit. Syst. III (1), p. 436, No. 93, ♂. 1793.

*Attacus laocon* CRAMER, Pap. exot. II, tab. 117, B. C.—V, pp. 179–180, var. STOLL, Suppl. Cram. tab. 42, fig. 2, ♂. 1790.

*Phaëna regia* ABBOT and SMITH, Lep. Ins. Georgia, II, tab. 61, ♀. 1797.

*Citheronia regalis* HÜBNER, Verz. Schmett., p. 153. 1818–1822.

*Ceracampa* KIRBY and SPENCE, Intr. Ent. II, p. 235; III, p. 179. 1828.

*Ceratocampa regalis* HARRIS, Cat. Ins. Mass., p. 72. 1835; Appendix to Hitchcock's Rep. Geology, Mass., p. 592, 2d edit., 1835; Rep. Inj. Ins. Mass., p. 287. 1841; Ibid., 3d edit., fig. 194. 1862.

*Dorycampa regalis* DUNCAN, Nat. Libr., XXXII, p. 161, Pl. 18. 1845.

*Eudes biocoon* WALKER, Cat. Lep. Het. Br. Mus., VI, p. 1372. 1855.

*Ceratocampa regalis* MORRIS, Synopsis Lep. N. Amer., p. 229. 1862.

*Citheronia regalis* PACKARD, Proc. Ent. Soc., Phil., p. 381, Nov. 1864.—GROTE and ROB., Annals Lyceum Nat. Hist., N. Y., VIII, p. 31. 1866.

*Ceratocampa regalis* BOISDUVAL, Annales Soc. Ent. France (4<sup>me</sup> sér.), VIII, p. 311. 1868.—BURMEISTER, Deser. Phys. Rép. Argentine V, Lép., p. 486. 1878; var. *brisotti* Larya, Atlas, p. 45, Pl. XIX, fig. 3. 1879.

*Ceratocampa* (*Citheronia*) *regalis* RILEY, Amer. Ent. I, p. 230, Pl. I, Aug. 1869.

*Citheronia regalis* var. *informalis* STRECKER, Papilio IV, p. 73. 1884.—var. *saengeri* NEUMOGEN, Ent. News, II, p. 151. 1891.—KIRBY, Syn. Cat. Lep. Het. I, p. 742. 1892.—NEUMOGEN and DYAR, Journ. N. Y. Ent. Soc. II, p. 150, Dec. 1894.—BEUTENMÜLLER, Bull. Amer. Mus. Nat. Hist. X, p. 441. 1898.—DYAR, List N. A. Lep. p. 76. 1902.

#### Larva.

(Pls. X-XIII, XXI-XXII, XXIII, fig. 1, XXIV-XXVI, LIV.)

Abbot and Smith, Lep. Ins. Georgia, II, Tab. 61. 1797.

Duncan, Naturalists' Library. Pl. 18, vignette p. 162. 1841.

Riley, Amer. Ent. I, p. 230. Pl. I, larva, pupa and imago, Aug. 1869.

Burmeister var. *brisotti*, Atlas, p. 45, Pl. XIX, fig. 3. 1879.

Packard, Proc. Amer. Phil. Soc., Phil., XXXI, p. 163, May, 1893.

*Imago*.—2 ♂, 2 ♀. Head and body orange-red, marked with cream-yellow ocher. Head orange, the tufts at the base of each antenna yellow. Collar yellow, broadly edged with yellow. Mesothoracic segment cream-yellow on the front edge, with a line of the same color passing back along the inner edge of the tegulae and ending at the base of the hinder edge of the hind wing. (This line is wanting in *C. azteca* and in *C. principialis*, but is present in *C. splendens*.) A median short thoracic slash extending nearly to the base of the abdomen (the thorax in *C. phoronea* being all yellow).

Fore wings in ♂ narrow, the apex pointed; outer edge very oblique in ♀, much wider, and the apex more obtuse; orange reddish-brown, two large cream-yellow spots at base of wing, one costal, the other at the base of the median vein (III), and the fold (V) well marked, like the longitudinal series, by a deep orange tint. A prediscal yellow patch, but no true discal spot, the veins being orange-red. A submarginal oblique row of seven oval longitudinal yellow spots parallel with the outer edge, the two near the costa the largest, the third one-quarter smaller, none in the extradiscal space, a larger one in the succeeding space, and one of the same size on the inner edge of the wing; veins and their branches orange-red.

Hind wings much rounded, more so than in *C. azteca*, more reddish, less brown than the fore wings; base of the wings and the costal region and inner edge ocherous yellow, with a broad marginal, indistinct, very diffuse shade.

Under side much more yellow and paler yellow than above; the base of the fore wing, costal region, and inner edge yellow (edge of costa brown); the seven spots more or less connected; the veins as above. An orange-red discal spot, large, irregular, diffuse, on the fore wings; lunate in shape on the hind wings, and on the hind wings a faint, orange-red, scalloped extra-discal line.

Base of the abdomen with an oblong cream-white yellow spot. Abdomen orange-red, with a narrow yellow band on the front edge; beneath yellow.

Genitalia (Pl. LIX, fig. 8a; LX, figs. 2, 2a, 2b, 2c): The suranal plate forming a long, narrow style-like acute process; the upper claspers very large, convex, oval, seen from the side half as broad as long, flaring, simple with no process at the end; the claspers of the lower pair or harpes (fig. 2, b), forming two stout hooped processes, a little shorter than those of the upper pair, curved upward and divided at the end into two black, solid divisions, the ends of which are rough and spiny; these claspers are much larger than in *C. sepularis*, while the suranal plate is very much narrower; the genitalia on the whole are on a larger scale than in *C. sepularis*.

Expanse of fore wings, ♂ 116 mm.; ♀ 155 mm. Length of one fore wing, ♂ 57 mm.; ♀ 75 mm. Breadth of one fore wing, ♂ 26 mm.; ♀ 35 mm. Length of hind wing, ♂ 37 mm.; ♀ 50 mm. Breadth of hind wing, ♂ 28 mm.; ♀ 34 mm.

*Eggs*.—Slightly larger than those of *Eacles imperialis*. Length, 3.1 mm.; width, 2.8 mm. Oval, cylindrical, somewhat flattened; the shell is thin, parchment like, flexible; the surface with microscopical obscure pits irregularly hexagonal, the pits often only partially formed (Pl. XV, fig. 4). Between each of the bosses is a fine hair, as in *Eacles*.

For the eggs I am indebted to Miss Morton, who sent them June 25 from New Windsor, N. Y. They hatched July 11. The eggs nearly indistinguishable in shape and color from those of *E. imperialis*. The egg-shell is so transparent that just before the larva hatches it can be seen lying curled up on its side. The head is large and black, while the body is pale, with distinct yellow sutures. Also the black thoracic legs are visible, and the black spots, those on the thoracic segments, elongated; also the dark spines and certain large ocherous patches on the thoracic segments.

*Larva*.—Stage 1.—Length, 6 mm. The head is large, wider than the body, smooth and shining black all over, with a few fine dark hairs. The body is cylindrical, black all over, with no stripes or spots of a lighter hue. A pair of large, long dorsal horns on the first thoracic segment, ending in a peculiar bulbous swelling, and on each side of the segment is a smaller subdorsal spine one-third as long as the dorsal ones, which is simple at the end, tapering to a point, bearing a short fine near the middle, and ending in a stout bristle. On each of the second and third thoracic segments is a pair of dorsal horns on each side, or four to each segment. The outer or subdorsal horns are only a little more than half as long as the inner, but otherwise like the latter; the trunks are spiny, the spinules minute, sharp, nearly equal in size, there being about fifteen to each trunk or stem of the spine. The singular bulbous termination is flattened, rather deeply divided, but somewhat like a chestnut in shape, but wider in proportion, and each side is produced, ending in a blunt spine, with a stout thick base; the trunk is umber-brown, but the bulbous extremity is blackish brown.

On being touched the larva vigorously jerks its head and front body sideways.

Each of abdominal segments 1-7 has a pair of smaller sharp spines about one-third as long as the longest thoracic spines, which are bent just beyond the middle where it sends off a spur; the end bearing a stout, not very long bristle. Besides these there is a pair of subdorsal spines and a lateral smaller one situated above the insertion of the legs, or six spines to a segment. There is a single median spine on the eighth segment just like the shorter subdorsal ones on the thoracic segments in shape and color, and ending like them in a forked bulbous expansion. Also on the ninth segment is a smaller, shorter, single median dorsal spine, but regularly forked at the end, not swollen. On the tenth segment near the base are two stout, short spines, ending in four branches. Behind them at the end of the suranal plate are four minute spinulose piliferous spines, which are black, all the others in front being brown. The large, broad, squarish anal legs are corrugated on the side. All the legs, thoracic and abdominal, are black. The specimens died before molting.

According to Harris: "Color of body black above and beneath; an obsolete series of ferruginous lateral lines directed obliquely downward toward the tail, most conspicuous on the posterior half of the body; sixth and seventh segments ferruginous above; spines pale ferruginous, black at tip. July 21, a. m., it cast off its skin. July 25, cast its skin again." (Correspondence, p. 297.)

The following description is drawn up from specimens bred at Providence, and described October 10. They fed on hickory, and were sent to Mr. Bridgham from Georgia.

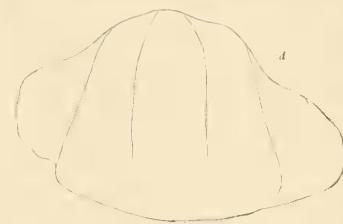


Fig. 18.—Penis-sheath of *C. regalis*.

*Stage II.*—(Probably stage II, as the increase in size between the latter stages is very marked.) Length, 25 mm. The head (width, 2.8 mm.) is rather large, rounded, as wide as the body, smooth and shining, mahogany brown, with two faint black shades converging toward the apex. The body is somewhat slender, the skin smooth and dull flesh-brown, with smoky blackish marks, the spines and spinules a little paler than the body and tipped with black. The prothoracic segment is broad, the front edge raised and flaring, with a transverse row of six black spines, four dorsal and one subdorsal; of the four dorsal the inner two are about as long as the body is thick, and sharp at the end, with long spinules; the two adjoining spines are minute. The four spines on the second thoracic segment are much larger, the outer ones on the second and third thoracic of nearly the same size, but the inner two on the third thoracic segment are a little longer than those on the second.

The spines on abdominal segments 1-8 are of even size, and armed with long spinules; they are about two-thirds as long as the body is thick, and end in two long diverging spinules. On



FIG. 19.—Armature of *Citheronia regalis*. Stage I. *a*, the first abdominal segment, showing the relative position of the spines: *sp.*, spiracle; *b*, one of the dorsal prothoracic "horns"; *c*, one of the dorsal horns of the third thoracic segment; *d*, one of the dorsal abdominal spines, those on segments 1-6 not differing in size or structure, near the base are two minute blunt setae; *e-h*, the armature of the last three abdominal segments; *e*, the caudal horn; *f*, the subdorsal spine of the same (eighth) segment; *g*, one of the dorsal spines of the ninth segment, which is evenly forked at the end; *h*, one of the large lateral spines arising from the suranal plate (*x*); *x*, the end of the suranal plate. All the figures drawn with the camera to the same scale.

the eighth segment, arising from a large, fleshy base, is a much spinulated caudal spine, nearly half as long as the large thoracic ones; it is mostly black, but flesh-colored in the middle. Behind it, on the ninth segment, is a median dorsal horn, about one-third as large as that on the eighth.

The suranal plate is small, rough, bearing two large spines; the end is rounded, with two minute spines between the last pair of lateral spines; the anterior two of the spines on this plate are larger, but simpler than those on the ninth abdominal segment, and end in four spreading spinules, the main stem being nearly smooth.

The prothoracic segment is blackish, reddish dark flesh color in the middle; the second thoracic segment is of nearly the same color, but the third is entirely black. The stigmata are black, surrounded by a blackish cloud, while in front is a velvety black oblique dash, and beneath a flesh-colored oblique raised ridge or fold. All the legs, both thoracic and abdominal, are black; the anal pair are large, rough, and black. There is a large spine under each spiracle.

*Stage III.*—Length, 30–35 mm. Molted on the morning (9 a. m.) of October 10. When first seen the color of the body was uniformly purplish flesh color, with black markings. The head (width, 4 mm.) is dark chestnut brown, with the clypeus and adjoining parts pale. It differs from the preceding stage in the considerably shorter abdominal spines, while their spinules are somewhat larger in proportion than in the previous stage. The thoracic spines are about or a little more than twice as long as the body is thick, and the abdominal spines are about one-third as long as the body is thick. The lateral oblique fleshy fold on the abdominal segments have a more distinct dark dash above than in the preceding stage. The legs are black. The caudal spine is now about one-third as long as the larger thoracic ones, being in the former stage about, not quite, one-half as long as the longer thoracic spines. Pl. LIV, figs. 2, 3.

By 2 p. m., October 10, the thoracic and caudal spines, at first pale flesh color, became black, and the head and thorax, as well as the body generally, had turned darker.

It assumes, like *E. imperialis* and *A. hisetor*, a Sphinx-like attitude, so that this feature is possibly inherited by the Sphingidae from the Ceratocampidae or a similar group. The thoracic and caudal spines are somewhat sensitive to touch by an intruder.

*Last stage.*—I will first describe an alcoholic specimen, 45–50 mm. in length, which at first I thought must belong to a fourth stage, or at least one before the last, but, as the head is of nearly the same size as full-grown specimens, I am inclined to regard it as simply a belated individual, or one which had recently molted, and had not fed up so as to fill out to its full size.

Length of body, 45–50 mm.; breadth of the head, 6.5 mm. The head is yellowish brown, with a dark spot on each side of the head opposite the apex of the clypeus. The two dorsal prothoracic spines are nearly as long as the head is wide, but without the long slender spinules of the previous stage; they are yellowish, but black on the distal third; the third or metathoracic pair are a third longer than the body is thick, and, like the others, with short, stout spinules. The abdominal spines are now much shorter than before, with short spinules, though slightly longer than in the fully grown examples. The "caudal spine" on the eighth abdominal segment is as in the full-sized specimens. The general hue of the body is as in the full-grown larva, but the thoracic dorsal black spots are smaller, though the metathoracic segment in front of the horns is deeply stained with black.

*Full-grown larva.*—Length, 125 mm.; thickness of the body, 20 mm.; width of head, 7 mm. The head is about one-third as wide as the body, rounded, smooth, free from hairs, and yellowish, not spotted on the sides, and not banded as in *Eacles imperialis*. The body is cylindrical; the skin smooth and shining, not granulated, as in Adelocephalia and Eacles. The two middle prothoracic spines are large and long, being nearly as long as the head is wide, but the spinules, like those of the other "horns," are now short, thick, and acute, not long and slender as in the previous stages; length, 6 mm.; they are yellowish and black on the outer third. This and each segment of the body succeeding have six well-developed spines, except the eighth and ninth abdominal, which have each an additional spine, the large median one. The two large median horns on the two hinder thoracic segments are each about 20 mm. in length; the horns of the second row corresponding to the subdorsal or supraspiracular row of the abdominal segments, being about half as long (10 mm.) as the dorsal ones; they are also yellowish and blackish on the outer third. All the six abdominal spines of segments 1–7 are now very small, slender, and only about twice as long as the large dorsal horns are thick at the base, viz., 4 mm. in length. Unlike the full-grown Eacles, the supra- and infraspiracular spines are as well developed as the dorsal ones. On the eighth and ninth abdominal segments the "caudal horns" are supplemented by two small, slender spines (7), situated just behind the large median horn. Length of the "caudal horn" on the eighth segment, 9 mm., that on the ninth segment being one-half as long. The suranal plate is triangular, the surface rough, with two small tubercles on each side, but no spines. The anal legs are very large, subtriangular, with the outer surface rough, and on the lower edge above the planta is a group of seven or eight minute spines; a similar group of minute spines occurs near the end of the middle abdominal legs.

For the colors the reader is referred to the hand colored photographs reproduced in Pls. XXI–XXIII of the living caterpillar. We have not yet seen a full-grown living larva. The

foregoing description has been drawn up from four well-preserved alcoholic specimens and a blown one.

This larva differs generically from Eacles in having well-developed dorsal spines on the prothoracic segment, while the lateral ones along the abdominal region are also well developed, these being nearly obsolete in Eacles. The genus *Citheronia* is unique in having 7 spines on the eighth and the ninth abdominal segments, respectively. All these characters are seen to be secondary and adaptive, and yet they are good generic characters, showing that the acquirement or loss of generic characters is due to adaptations to the surroundings. The specific characters are well brought out by comparing *C. regalis* and *C. sepulralis*.

#### RECAPITULATION OF THE SALIENT FEATURES IN THE ONTOGENY OF CITHERONIA REGALIS.

##### A.—Congenital characters of the larva, as seen in stage I.

1. The three pairs of enormous spines, the first or prothoracic pair but little shorter than the third, and the middle pair about two-thirds as long as the body, all ending in a swollen, triangular, two-horned flattened bulb; these appendages being deterrent and for offensive use in the earliest as well as latest larval life.
2. Both the eighth and ninth abdominal segments bearing a high median dorsal horn, and these segments bearing 7, instead of only 5, spines.
3. The lateral spines on the abdominal segments nearly as large as the dorsal ones.
4. Body dark; head dark in color.

##### B.—Evolution of later adaptational characters.

1. The bulbous tips of the thoracic horns dropped at the end of stage II.
2. The thoracic horns become curved in stage II or III.
3. The thoracic dorsal spines become much stouter, with much shorter and stouter spinules at the last molt.
4. The mature larval features mostly assumed in stage III.
5. The dark colors exchanged after the last molt for pale green, with bluish tints.
6. The black dorsal thoracic spots and the lateral yellowish bands most showy in the last stage.

Attention should be drawn to the colossal size of this larva, as compared with that of *Adelocephala* and even *Eacles*, though the head is not so much larger. This is due, perhaps, to its sluggish life, greater digestive and assimilative powers, so that a rapid acceleration of the growth of the body takes place; owing to its protection from the attacks of birds, it may feed openly and continuously. It is thus similar to sphingid and attacine larvae in its huge body and enormous appetite. The largest coeliopod larvae are the spiny ones, and the spiny or tuberculated *Saturnians* and *Attacine* have thick, large bodies.

*Pupa*.—Pl. LVI, fig. 7; Pl. XXXV, figs. 2, 2a, 2b, 1 ♀. Body thick, head well rounded; body smooth, with no such spines as in *Eacles* either on the head, thorax, or abdomen. The maxilla long, though a little shorter than in *Eacles*; these, as well as the parts of the head in front, and the legs, are more convex on the surface than in *Eacles*. Antennae slightly narrower and smaller than in ♀ *Eacles*. The abdominal segments smooth on the hinder edge, there being little pits instead of low spines. End of the abdomen very blunt and rounded, the cremaster reduced to a vestige not so long as broad, irregularly conical, with two short thick divergent tubercles at the end. No spines on the fore or hinder end of the abdominal segments.

Length, ♀, 60 mm.; thickness, 23 mm.

*Food plants*.—Black walnut, butternut, hickory, persimmon, sunnach, sweet gum, sycamore, and ash. Found on the lilac in St. Louis (Kern ex Riley).

Destroyed a considerable number of cotton plants in Natchitoches, La., in September, 1890 (Riley); did considerable damage to sea-island cotton in Bradford County, Fla., 1891 (Riley).

*Odor of the pupa and moth*.—Riley states: "Both the chrysalis and the moth have a characteristic strong odor which can not easily be described for lack of comparison, though it

reminds us forcibly of the peculiar odor of the English Broad Bean." I can confirm this statement as regards the pupa. Its smell reminds one of the odor perceived in shelling beans, and also recalls that of crushed lettuce and of laudanum. It is quite strong and like that of *Spilosoma* and of *Estiguene aerua*. It smells more at the end of the body than near the head, doubtless the glands being near the rectum.

*Habits.*—It changes to a chrysalis in the earth. As early as July 20, 1832, Doctor Harris found on the black walnut a freshly hatched larva of this regal moth, and a few days later, on the 4th or 5th of August, he discovered two large flattened eggs from which similar larvae were at that time hatched. It shed its skin July 21, a. m., and molted again July 25. Riley states that it is single-brooded in Missouri. It sometimes remains in the ground, in the chrysalis state, fully eleven months of the year. "The moths in the latitude of St. Louis usually issue during the last half of June, and the caterpillars are found full-grown from the middle of August to the middle of September." (Riley.)

While this fine species is very rare north of New York it is also scarce in the Middle and Southern States. The Texan ♀ collected by Mr. Boll differs from the northern examples in wanting the hinder spots on the fore wings.

In Georgia it is said by Abbot and Smith to be double-brooded. The moth is known as the regal walnut moth, and the caterpillar as the "hickory horned devil."

*Feeding habits of the moth.*—Mr. Druce while sugaring for moths observed on the trunk of a small ash tree a splendid *C. regalis* sipping the sugar with all the enjoyment of a *Catocala* (*Papilio* ii, p. 188). Mr. R. Bunker has observed, according to Grote, that *C. regalis* "occasionally comes to bait after the fashion of a *Sphinx*" (*Hawk Moths of North America*, Bremen, 1886, p. 55).

*Geographical distribution.*—This species has not yet been detected north of Cambridge, Mass. (Harris); Larva from North Leverett, Mass. (Mus. Comp. Zool.); Providence, R. I. (H. L. Clark, T. E. B. Pope); Foster, R. I. (T. E. B. Pope); Phoenix, R. I. (W. W. Bailey); New Jersey (not common; generally distributed, Smith); New York (Grote, Joutel); Ithaca, N. Y. (Slingerland); Missouri, southern Illinois, where it is quite scarce (Riley); New Harmony, Ind. (Mus. Comp. Zool.); Peoria, Ill. (Dr. Ordway, M. C. Z.); Kentucky (F. G. Sanborn, M. C. Z.); Crescent City, Fla. (H. G. Hubbard); Woodville, Miss. (Phares) (not uncommonly met with); Dallas, Tex. (Boll); Louisiana (W. Sargent, M. C. Z.).

Whether North Leverett, Mass., is in a cooler, more northern region than Cambridge we do not know; it is in the Connecticut Valley, lat. 42° 30', and in presumably as mild a climate as Cambridge. In our Map VIII we have drawn a loop up the Connecticut River at Leverett.

The southern limits of this moth have not yet been worked out. It has not yet been reported from Texas; it is not mentioned by Druce (*Biologia Centrali-Americanica*) as occurring in Central America. What is mentioned by Burmeister as *C. regalis*, is *C. heissotti*, but no locality is given, and we take it, this example came from Rio de Janeiro. The locality of Cramer's specimen is given as Bengal, while Stoll's example is stated to have been collected in North America.

*Larval behavior.*—Doctor Harris thus describes the behavior of three young larvae: "They were just hatched at the time, and the caterpillars were near to them, resting on a leaf. The position of these young insects was so peculiar as to attract attention, independently of the long branching spines with which the fore part will have to follow the original of their body was armed. They were not stretched out in a straight line, neither were they hunched up like the caterpillars of the *Luna* and *Polyphemus* moths; but, when at rest, they bent the fore part of the body sideways, so that the head nearly touched the middle of the side, and their long horn-like spines were stretched forward in a slanting direction over the head. When disturbed, they raised their heads and horns, and shook them from side to side in a menacing manner." (Treatise Ins., p. 400.)

Riley, speaking of the "truly formidable" caterpillar when fully grown, adds: "While a peculiar habit which it has of spitefully wriggling from side to side, very unlike the up-and-down movement of the *Sphinx* tribe of caterpillars, gives it a still more menacing appearance, yet it is entirely harmless and can not possibly hurt anyone, for, as we have proved by experiment, the

prick of its spines has no poisonous effect whatever. Mr. Abbot tells us that this caterpillar is called in Virginia the hickory-horned devil, and that, when disturbed, it draws up its head, shaking or striking it from side to side; which attitude gives it so formidable an aspect that no one, he affirms, will venture to handle it, people in general dreading it as much as a rattlesnake." (Amer. Ent., I, p. 230.)

Wallace, in his "Darwinism," remarks that the green color of this larva "suggests that its ancestors were once protectively colored, but, growing too large to be effectually concealed, it acquired the habit of shaking its head about in order to frighten away its enemies, and ultimately developed the crown of tentacles as an addition to its terrifying powers" (p. 210). This is somewhat fanciful, for the caterpillars of Citheronia have not only a "crown of tentacles," but similar spines at the end of the body, with smaller ones along the middle of the body, and the luxuriant armature is evidently inherited from its Adelocephala ancestors. The great development of the spines may, as we have suggested (Pt. I, p. 16), have arisen in response to the stimuli of blows on the more exposed parts of the body.

*Sexual differences in the larva of Citheronia, etc.*—Burmeister, in referring to the larva of *C. brissotii*, which he considers as a variety of *C. regalis*, speaks of the caterpillar of *C. regalis* figured in Abbot and Smith as representing an individual of the feminine sex. His own figure, however (Pl. XIX, fig. 3), is that of a male. "toujours plus petit dans ce genre."

*Parasites*.—In the Loew collection of the Museum of Comparative Zoology is a large species of Tachina, *Belvosia bifasciata*, bred from *C. regalis*.

*Variations*: Var. *infernalis* Streeker. Head, body, and legs, deep orange or brick-red; wings above and below of the same color. Fore wings slate colored in the interspaces, only the veins red; a large red subapical spot near the costa, also a smaller one midway between it and the inner margin. Bred from a blackish-blue larva of the usual appearance. Maryland and North Carolina.

#### CITHERONIA BRISSOTTII (Boisduval).

*Ceratocampa brissotii* Boisduval. Annales Soc. Ent. France (4) VIII, p. 312. 1868.—KIRBY. Syn. Cat. Lep. Het. I, p. 742. 1892.

*Ceratocampa regalis* var. *brissotii* BURMEISTER. Deser. Rép. Argentine, Lép. Atlas, p. 45, pl. xix, fig. 3. 1879.

##### Larva.

(Pl. XVI, fig. 3.)

*Burmeister*, Deser. Rép. Argentine, Lép., p. 45. Atlas, pl. xix, fig. 3. 1879. (♂ drawn from a dried blown specimen.)

The figure of the larva (Pl. XVI, fig. 3) is undoubtedly drawn from a poorly preserved specimen. In fact the armature of the larva of Citheronia figured by Burmeister seems to be inaccurately drawn. Burmeister states that it differs from the larva of *C. luteum* (*C. ixion*) in having longer spines, though otherwise the same, while they are of the same orange color, with a black tip.

Three ♀♀ in the Museum of Comparative Zoology, brought by Prof. L. Agassiz on the Thayer expedition, exactly agree with Boisduval's description. It differs from *C. regalis*, to which it is closely allied, in the middle series of yellow spots being united into a continuous band, and in the presence of a submarginal zigzag orange-red line.

It appears to be a rarer species than any other in Brazil.

*Food plant*.—In Brazil, according to Burmeister, it feeds on *Exacaria biglandulosa*, an euphorbiaceous plant.

*Geographical distribution*.—Lagoa Santa, Cantagalli; this latter town is a few miles up in the interior from Rio Janeiro. (Museum of Comparative Zoology.)

## CITHERONIA MEXICANA Grote and Robinson.

Pl. XVIII, fig. 4, ♂.

*Citheronia mexicana* GROTE and ROBINSON, Annals Lyceum Nat. Hist. N. Y., VIII, p. 32, Pl. XIII, fig. 1, Oct., 1866.

*Eacles mexicana* DRUCE, Biol. Centr. Amer. Lep. Het., I, p. 169; Tab. XV, fig. 11, ♂, June, 1866.

*Citheronia mexicana* KIRBY, Syn. Cat. Lep. Het., I, p. 743. 1892.

*Imago*.—1 ♂. Compared with *C. regalis* ♂ it is smaller than any I have seen. Like that species the number of pairs of fully developed antennal pectinations is 17-18. The fore wings are slightly more acute at the tip, and the hind wings decidedly more triangular, the apex being much less rounded than in *C. regalis*. The fore wings are darker, of a peculiar dull almost purplish gray, a little duller than in *C. splendens* and *C. azteca*. The yellow spots are the same in arrangement and size as in *C. regalis*, but more reddish. It differs decidedly from *C. regalis*, and in this respect resembles *C. phoronea* and *aurota*, in having a submarginal brick-red zigzag line, with some yellow in it, which runs parallel with the outer edge of the wing. The hind wings are colored and marked as in *C. regalis*. The wings beneath are much as in *C. regalis*, except that the submarginal zigzag line is present. The thorax and abdomen are as in *C. regalis*.

*C. mexicana* entirely differs from *C. splendens* and *C. azteca* in the spots on the fore wings being reddish ocherous instead of ocherous white, and in having a submarginal line on the fore wings.

The tongue is well developed, fully as much so as in *C. regalis*.

Expanse of the fore wings, 90 mm. (♀ according to Grote, 5.80 inches); length of one fore wing, 46 mm.; breadth of one fore wing, 20 mm.; length of one hind wing, 28 mm.; breadth of one hind wing, 20 mm.

*Pupa*.—"Scarcely distinguishable from that of *C. regalis*, except that it is much smoother and the spinules much larger in size. They are also raised considerably above the surface of the segments. The cremaster is also smooth at its tips." (H. Edwards, Ent. Amer., IV, p. 62.)

*Geographical distribution*.—Orizaba, Coatepec, Mexico; City of Guatemala, Vulcan de Chiriquí, Panama (Druce).

## CITHERONIA SPLENDENS (Druce).

Pl. XVIII, fig. 2 ♂, 2a ♀; larva, Pl. XV, fig. 1.

*Eacles splendens* DRUCE, Biologia Centr. Amer. Lep. Het., I, p. 169, Pl. xv, fig. 12, June, 1866.

*Citheronia splendens* KIRBY, Syn. Cat. Lep. Het., I, p. 742. 1892.

Druce states that this species is closely allied to *C. regalis*, from which it differs in the entirely different coloration of the hind wings, in having the thorax striped and the yellow marks at the base entirely absent, and also in the general grayer color of the wings of both pairs.

That it is quite distinct from *C. regalis* is proved by the difference in the larvae of the two species.

*Geographical distribution*.—Guanaguato, Mexico (Boucard, Druce).

*Larva*.—Stage before the last. Length, 62 mm.; width of head, 6 mm. (that of *C. regalis* in same stage, 7 mm.). The head of the usual shape, being rather flattened in front; as wide as the prothoracic plate; dark chestnut, and differing from *C. regalis* of the same stage not only in the ground color being darker, but in the front being black on each side of the clypeal region, while the center of the clypeus-posterior is black. Prothoracic plate rugose, light colored, with a black band on each side of a pale median line, and another above each spiracle; armed with a dorsal pair of large high spines about two-thirds as long and thick as those of the second thoracic segment (4 mm. in length), broad and blunt at the end, not terminating in a sharp point, as in *C. regalis* or in a bulb as in *C. laevicollis*; they are black, yellowish at the base, and bear about 10 to 12 large swollen blunt tubercles, each ending in a short, stout seta. The supraspiracular tubercles are not one-half as long as those of the dorsal pair. The one directly in front of each spiracle is a little shorter, but that at the base of each leg is stouter and larger, ending in five

spines; second and third thoracic segments each with eight spines, the dorsal tubercles alike in shape and size, high but blunt at the end (length 5 mm.; that of *C. regalis* 16 mm.), as thick at the end as at the base, not tapering to a sharp point, as in *C. regalis*. The supraspiracular spines about half as long but quite as thick at the base as the dorsal ones; the two lowermost spines flat and short.

All the abdominal dorsal spines of the same size and nearly of the same shape, with the same number (5) of teeth on spinules. On abdominal segments 1-7, those without legs (1, 2, and 7), there are eight black spines; on those segments with legs (3 to 6) the lowest spine is wanting. On segments 8 and 9 there are four spines on each side of the median dorsal one. That on the eighth abdominal segment is large and thick, 4 mm. in length and slightly but unevenly bifid at the tip. That on the ninth segment is much thicker and about one-quarter longer than the others on the same segment, and ends in two diverging short spines, more distinctly bifid than the median spine on the eighth segment.

Suranal plate long and narrow, rugose; black; a lateral stout 4-toothed spine or tubercle on each side near the middle of the plate; the edge is armed with spines as long as those of *C. sepulcralis*. Body blackish; the pleural ridge yellowish. In this form the number of dorsal thoracic spines is 10, as in *C. regalis*, but they are remarkably short and thick and blunt at the end.

I am indebted to Dr. Dyar for the opportunity of examining this very rare larva, a poorly preserved blown example in the U. S. National Museum. For the details of the armature see Pl. LV, figs. 1, 1a, 1b.

From *C. lucuum (ixion)* larva it differs in the shorter spines, the spinules being remarkably large and swollen; also in the equality in size of the dorsal spines on the second and third thoracic segments, while the eighth abdominal median spine (caudal horn) is nearly twice as thick.

#### CYPHERONIA AZTECA (Drury).

PL XVIII, fig. 3j.

*Eucles azteca* DRUCE, Biol. Centr. Amer. Lep. Het. II, p. 413; Tab. 80, fig. 1, Sept. 1897.

*Imago*.—1 ♂. This form is very near *C. regalis*, but differs in the fore wings being sharper at the apex; the outer edge a little more oblique; apex of the hind wing more produced, and not so much rounded. The fore wings are of the same color and the markings are identical, but the hind wings are more yellowish; not only the costal and inner edge, but the outer edge is yellow. There is a distinct, though very diffuse, dark gray extradiscal band, beyond which the wing out to the outer edge is yellow.

Under side of the wings cream-white, not so ochreous as in *C. regalis*. The spots of the extradiscal series are separate. Hind wings as in *C. regalis*, but cream-white; the markings are the same. There are in my single ♂ no yellow thoracic lines, but they are present in the ♀ figured by Mr. Druce.

Expanse of the fore wings, ♂ 120 mm.; length of a single fore wing, ♂ 55 mm.; breadth of a single fore wing, ♂ 23 mm.; length of a hind wing, ♂ 33 mm.; breadth of a hind wing ♂ 25 mm.

This species differs from *C. splendens*, to which it is closely allied, in the outer margin of the hind wings being ochreous. The two species may prove to be the same when reared from the larvae. The markings of the fore wings are identical. In my single male, the thorax is almost entirely brick red, without the yellowish white stripes of *C. splendens*.

*Geographical distribution*.—Jalapa (Barrett); Orizaba (Druce).

## CITHERONIA PRINCIPALIS (Walker).

Pl. XIX, fig. 8 ♀.

*Euches principalis* WALKER, Cat. Lep. Het. Br. Mus., VI, No. 8, p. 1376. 1855.  
*Ceratoctampa principalis* BOISDUVAL, Annales Soc. Ent. France (4), VIII, p. 316. 1868.  
*Citheronia principalis* KIRBY, Syn. Cat. Lep. Het., I, p. 742. 1892.

*Larva.*

Pl. XVII, fig. 4.

*Boisduval*, J. A., Annales Soc. Ent. France (4), VIII, p. 317. 1868.

*Burmeister*, Descr. Rép. Argentine, Lép., Atlas, Pl. xx, fig. 4. Pupa, fig. 6. 1879.

*Imago*.—1 ♀. Thorax, abdomen, and wings tawny or reddish orange-brown; tufts at the base of the antennae, and two on top of the metathorax, ocher in color, as also two yellow spots at the base of the fore wings, one on the costal edge and the other at the base of the cubitus (Vein IV). Fore wings with the basal line distinct, situated much nearer the discal mark than the base of the wing; it is dislocated on the cubitus or median vein, where it makes a right angle, and extends to the costa, being parallel with the costal mark; it is brown, shaded diffusely within with gray. Discal mark a long, narrow, straight streak, gray, within edged with dark brown. A distinct oblique, firm, not wavy, extradiscal line extending from the outer third of the inner edge to the outer sixth of the costal edge; it is brown, edged externally with gray. On the inside of the line is a row of five roundish spots; the two nearest the costa obscure deep orange; the two next in the extradiscal cell and the other in the cell behind are hyaline, with a few yellow scales scattered over the surface and on the edges; the anterior one is roundish, the other triangular; the anterior spot is about halfway between the discal mark and the outer edge. Between the extradiscal line and the outer edge of the wing are two alternating rows of deep orange-red irregular blotches. Fringe of both wings reddish brown.

Hind wings like the anterior ones in color and marking, with no yellow, basal and extradiscal lines as on fore wings, discal mark as on fore wings, and the two alternating rows of orange spots are present.

Under side of wings paler, reddish brown; no distinct discal marks on the wings of either pair; basal line wanting, but the extradiscal forming a brown shade. The five spots within it nearly as above, including two hyaline spots. The submarginal alternating rows of spots are represented by a very irregular, zigzag brown line, edged within with dull yellow ocher on both pairs of wings. For the venation see Pl. LVIII, figs. 3, 3a.

Expanse of the fore wings, ♀ 114 mm.; length of one fore wing, ♀ 62 mm.; breadth of one fore wing, ♀ 31 mm.; length of hind wing, ♀ 40 mm.; breadth of hind wing, ♀ 30 mm.

This is a large species with the fore wings narrower, more elongated, and pointed at the apex than in *C. phoronea* var. There are no yellow spots on the wings; the hind wings are more produced toward the apex. My specimen was compared with Walker's type in the British Museum, exactly agreeing with it.

*Egg*.—The eggs taken from the abdomen of a dried ♀ are of the same shape, the shell similar, with apparently the same style of sculpturing as that of *C. regalis*. The egg only differs in its smaller size. Length, 2.4 mm.; breadth, 2 mm.

*Larva*.—Fig. 4. Armed with six rows of spines, of which four on the second and third segments are much longer than the others and curved backward; that on the eighth abdominal segment longer than the others, and like a queue. The prothoracic segment with six spines, of which the median two are half longer than the others (Boisduval).

Judging by Burmeister's figure, it differs from the larva of *C. phoronea* in the four dorsal thoracic spines being shorter, more pointed, while the dorsal and other abdominal spines are longer than in that species. Moreover, it differs from all the other species in the body being barred obliquely, as in Sphinx larvae, with seven stripes on each side, the upper part of each bar being edged with brown. Anal legs and suranal plate very spiny.

*Pupa*.—The chrysalis is, according to Burmeister, much like that of *E. imperialis*, but it is less than half as large and the spines on the surface of the body are finer.

*Geographical distribution*.—Brazil (Boisduval, Burmeister).

*Food plant*.—Not mentioned by Burmeister.

#### CITHERONIA PHORONICA (Cramer).

*Phalena-Attacus phoronea* CRAMER, Papillons Exot., III, p. 77-78, Taf. 239, A-C. (1780?). 1782.

*Phalena-Attacus laocoon* DRURY, Illustrations Exot. Ent. III, Tab. 3, fig. 1, ♀. 1780. No. 1601.

*Citheronia phoronea* HÜNER, Verz. bekannt. Schmett., p. 153. 1818-1822.

*Cossus laocoon* WESTWOOD edit. Drury, Illustr. Exot. Ent., III, p. 3, Pl. 3, fig. 1, ♀. 1837.

*Eacles phoronea* WALKER, Cat. Lep. Het. Br. Mus., VI, p. 1375. 1855.

*Citheronia phoronea* GROTE and ROBINSON, Annals Lyceum Nat. Hist., VIII, p. 30, 36. Oct., 1866.

*Ceratocampa phoronea* BOISDUVAL, Annales Soc. Ent. France (4), VIII, p. 310. 1868.—BURMEISTER, Deser. Phys. République Argentine. Larva, Atlas, p. 44, Pl. xix, fig. 1. 1879.

*Citheronia phoronea* KIRBY, Syn. Cat. Lep. Het., I, p. 743. 1892.

*Citheronia aroa* SCHAUS, Journ. N. Y. Ent. Soc., IV, p. 59 (♂). June, 1896.

#### Larva.

Pl. XVI, fig. 1.

Burmeister, H., Deser. Phys. Rép. Argentine, p. 44. Atlas, p. 44, Pl. xix, fig. 1. 1879.

*Imago*.—Boisduval describes the female as resembling *C. ixion*, but of larger size. Its fore wings are reddish brown, becoming violaceous toward the apex and on the costa; discal spot large, yellowish gray, marked with four small blackish spots, and beyond an oblique transverse band formed of clouded yellow spots, the two anterior of which are larger and oval. Beyond on the violaceous margin is a zigzag yellowish line, and at the base of the wing a bright yellow spot. The hind wings are reddish, tinged with violaceous, with the costal edge marked with yellowish, an anal spot, and a submarginal sinuous clear yellow line. The thorax is yellow, with the collar and a broad median spot of a violet-brown. Abdomen rust red, with yellow wings. The male is smaller, and only differs in the hind wings being yellow with a ferruginous band, and a transverse wavy violet-brown line. This species is very rare in our collections.

The following description is drawn up from a ♂ in the Neumoegen collection of the Brooklyn Institute:

It differs from *C. laocoon* (*C. ixion*) in the much longer and sharper fore wings, the outer edge of which is much more oblique. The hind wings are not quite so rounded at the apex. The coloration is very different and the head and thorax are dark red-brown, as on the fore wings; patagia pale ochreous, extending on the fore wings along the axillary vein (VI); a curved discal mark situated in a large yellowish cloud; an oblique extradiscal row of eight yellow spots obscured by reddish brown; a submarginal irregularly scalloped line as in the female.

Hind wings yellow-ocher and red, ochreous at base and in the middle of the hinder edge, and a submarginal scalloped yellow line as in the ♀. The abdomen is ringed with yellow.

Beneath, more yellow-ocher than above. Discal patches distinct, extradiscal and submarginal lines distinct. Hind wings nearly all yellow.

Expanse of fore wings, ♂ 193 mm.; length of one fore wing, ♂ 47 mm.; breadth of one fore wing, ♂ 20 mm.; length of a hind wing, ♂ 27 mm.; breadth of a hind wing, ♂ 21 mm.

*Citheronia aroa* Schaus is very closely allied to *C. phoronea*, and I am inclined to regard it as a local variety. It differs from my Rio ♀ specimens, judging by Druce's figure, in the broad extradiscal ocher band being in the middle and hinder part of the wings broken up into separate spots, while the hind wings have a ground color of ochreous, not brick-red as in *phoronea*. The colors of the body are identical in the two forms.

*Larva*.—Burmeister gives a figure which we copy, and describes it as having on the first or prothoracic segment "four" [two] large spines of a clear rose color, the two small lower ones being scarcely visible. The following segments have six spines, becoming successively smaller going backward, the lateral ones each ending in a black tip bristling with short hairs; the two

middle dorsal ones are a little larger. The "penultimate segment" (eighth abdominal one) has a high median dorsal spine, and two on each side, the last segment having only four spines. In fact, the larva is represented as being closely similar to that of *C. regalis*, differing chiefly in the spines being bristly rather than spiny.

*Larva*.—(Pl. LV, fig. 3.) What appears to be the larva of this species is represented by certain alcoholic specimens in the Museum of Comparative Zoology at Cambridge, Mass., two from Mondez, Brazil (Thayer Expedition), and one from Macacos, Brazil (Roberts).

Length, 70 mm. Compared with the blown larva of *C. laocoon* (*C. ixion*) in the U. S. National Museum, it differs in the following respects: The dorsal and subdorsal thoracic spines are shorter, stouter, and the spinules on them are larger and much more crowded. They are otherwise the same, being black at the swollen tips. The caudal horn is at least one-third shorter, stouter, thicker at the base, subconical, and the spinules on it are more prominent and more crowded.

The dorsal spines on abdominal segments 1-7 are of the same size and shape, there being no essential difference.

Suranal plate not so smooth and free from low spines as in *C. laocoon*, there being 10-11 tubercles or granulations on each side, and one of them being much larger than the others and 5-headed, though not so high as broad.

The spines around the edges of the anal legs are also larger and more prominent. (For details of the armature, see Pl. LV, fig. 3.)

Burmeister states that the anterior spines of *C. ixion* (*C. laocoon*) are higher and the black end swollen, and bristling with hairs; also that the upper lateral spines of the thin thoracic rings are smaller. From this we infer that the specimens before us are most probably the larva of *C. phoronea*, rather than of *C. principallis*, the other Brazilian species.

His figure of *C. ixion* also shows that the middle spine on the suranal plate is higher, more prominent.

*Food plant*.—Burmeister states that it eats the parasitic plant called by the Brazilians *fruta de erbe*, the botanical name of which he did not know.

*Geographical distribution*.—French Guiana and Brazil (Boisduval), Rio de Janeiro (Burmeister). Burmeister says that the drawing of the larva was made by his son at Rio de Janeiro, but he does not state whether it occurs in the Argentine Republic or not. Cramer states that "it is not at all common" at Surinam. Drury gives Rio de Janeiro as the habitat, and Walker Brazil. My specimen is from M. Doneckier; it has no locality label.

Schaus's *C. aroa* is from Aroa, Venezuela. Druce gives as the habitat Honduras and Venezuela (Aroa).

#### CITHERONIA LAOCOON (Cramer).

Pls. XVIII, fig. 1 ♂, XIX, fig. 9 ♀.

*Phalena Attacus laocoon* CRAMER, Papillons Exot., II, p. 30. Pl. cxvii, fig. A. 1779.

*Citheronia anassa* HUEBNER, Verz. Schmett. p. 153. No. 1600. 1818-1822.

*Eacles princeps* WALKER, Cat. Lep. Het. Br. Mus. VI, p. 1374. 1855.

*Ceratocampa laocoon* BOISDUVAL, Annales Soc. Ent. France (4), VIII, p. 314. 1868.

*Ceratocampa ixion* BOISDUVAL, Annales Soc. Ent. France (4), VIII, p. 315. 1868.

*Citheronia laocoon* KIRBY, Syn. Cat. Lep. Het., I, p. 743. 1892.

#### *Larva*.

Pls. XVI, fig. 2, LV, fig. 2.

Burmeister, Deser. phys. Rép. Argentine, Lépidoptères. Atlas. Pl. xix, fig. 2. 1879-80.

*Imago*.—1 ♂. Body and wings of the shape of ♂ *C. regalis* and *mexicana*. Ground color grayish orange, as in *C. regalis*. Antennae as in *C. regalis*. Head yellow, with a distinct median orange-red line on the front extending from the labrum upward, while the front in *C. regalis* is all orange-red. The maxilla are separate, extending beyond the palpi, being a little longer

than the latter. Thorax all yellow, as in ♀, with no orange streaks; abdomen orange, distinctly banded with yellow; tips yellowish.

Fore wings of the same shape as in *C. regalis*, base of wing yellow, with two long lobes; the discal blotches inclosed in the broad, large yellow band, which otherwise is as in ♀, extending to costa very near the apex. Five unequal dull orange-brown discal blotches, and beyond is an oblique series of six intervenular blotches. A submarginal, scalloped, dark orange line, not reaching the apex; this line not present in *C. regalis*. Veins orange.

Hind wings very different from the other species in being entirely yellow, except two unequal reddish blotches near the base, and an outer broad, diffuse, reddish shade beginning just before the apex and ending distinctly on the inner angle; in ♀ the wing is nearly all reddish, with a submarginal zigzag line.

Under side of wings nearly all yellow; a large, squarish, reddish discal blotch on the fore wings, a more irregular diffuse blotch halfway between the discal square and apex; outer edge of the wing gray orange-red, containing a yellow 5-7-scalloped line. Hind wings all yellow, except the discal spot and the narrow, wavy extradiscal line. For the venation see Pl. LVIII, figs. 4, 4a.

Expanse of fore wings, ♂ 88.5 mm.; length of a fore wing, ♂ 39 mm.; breadth of a fore wing, ♂ 18 mm.; length of hind wing, ♂ 25 mm.; breadth of hind wing, ♂ 18 mm.

No locality. In the Edwards collection of the American Museum of Natural History.

I have examined 3 ♂ and 1 ♀ in the Cambridge Museum, and find that they exactly agree with Boisduval's description.

One ♀ variety, and perhaps *laocoon* Cramer. A large species, with broad, short wings; much shorter than in *C. regalis*; costal edge more convex; apex squarish; outer edge full and convex, more so than in *C. principalis*, and hind wings shorter, broader, and apex rounder than in that species; the hind wings reach to the end of the abdomen.

Head and thorax bright ochre yellow, the thorax being entirely yellow, with no orange spots. Head deep orange-red in front but on the vertex and around the base of the antennae yellow; a narrow transverse orange-red line on the extreme front edge of the prothorax; abdomen orange, narrowly banded with ochre.

Fore wings with more yellow than in *C. regalis*; their insertion yellow. No definite basal and extradiscal lines. Three large discal spots, the innermost round, the others parallel and more or less broken up. The site of the extradiscal line is occupied by a series of intervenular large bright ochre spots, which are rounded on the outer edge, irregular on the inner, the longest one being on the costa, the three behind diminishing in size, that in the extradiscal space being the smallest one of the whole series. In the submarginal reddish brown space is a faint irregular zigzag deep orange red line. Fringe of both wings reddish.

Hind wings with more yellow than in *C. regalis*; ocherous at base as is the inner edge; a large ocherous spot on the costa; the hind wings are more reddish than the anterior ones, and with a coarsely zigzag submarginal reddish orange line edged internally with yellow. (The yellow in this zigzag line on both wings may predominate as in Drury's "laocoon.")

Underside of the fore wings orange at base, extending out on the discal cell, and along the inner edge; the extradiscal series of yellow spots as above. The hind wings beneath are yellow ochre, a large hemispherical reddish spot; a broad extradiscal reddish line, the outer edge reddish and yellow irregularly diffused. Abdomen yellow on the sides and beneath; a lateral row of reddish spots.

Expanse of the fore wings, ♀ 115 mm.; length of a fore wing, ♀ 56 mm.; breadth of a fore wing, ♀ 30 mm.; length of hind wing, ♀ 38 mm.; breadth of hind wing, ♀ 27 mm.

My ♀ specimen was compared with examples in the Paris Museum labeled *C. ixion* Boisd. It also agrees perfectly with Boisduval's description.

From an examination of the collection of this genus in the British Museum, which does not possess *laocoon*, I was led to regard my specimen described above as a variety of *C. phoronea*. It is intermediate between that and the type of Walker's *E. caticiens*. The thorax is yellow as in

*E. cecius*, the abdomen orange red, striped narrowly with yellow as in *C. briassotti* Boisd., and *C. regalis*. The fore wings are as in *E. cecius*, the hind wings as in *C. phoronea*. It is quite different from the ♀ of *C. briassotti*, which is near *mexicana* Grote. But I find that this same ♀ specimen agrees well with Cramer's figure of *C. laeocoon* ♂, though it is quite different from his figure of the ♀. There is, indeed, no important difference except that the discal spot in his figure is not double, but forms a single large yellow patch. The underside of my ♀ agrees well with Cramer's figure C of the underside, only differing in the three costo-subcostal yellow spots being connected, but otherwise the fore and hind wings beneath are marked in the same way.

I quite agree with the remark of Boisduval that Cramer's figures B and C of his Pl. CXVII represent *C. regalis*.

It appears, then, that Boisduval's *C. ixion* is a synonym of Cramer's *laeocoon*.

*Larva*.—Last stage.—Pl. LV, figs. 2, 2a. Length, 78 mm. Body of the same general shape as in *C. regalis*, thickest on the second and third thoracic segments. Head of the same width as the prothoracic plate, pale, of the same hue as the suranal plate. On each thoracic segment there are eight stout spines—four on each side—and there are ten long subequal dorsal spines or “horns.” On the front edge of the prothoracic segment the two dorsal spines are large and high and of the shape and about two-thirds of the size of those on the second and third segments; those of the supraspiracular row small, about one-fourth as long as those of the submedian row, but slenderer. One directly in front of each prothoracic spiracle is low, stout, conical, about one-half as large as that in the lower or infraspiracular row. Of the four dorsal horns of the second thoracic segment, *each are of the same size, length, and thickness*; those of the supraspiracular row no sa aller or shorter than those of the dorsal series. On the third thoracic segment they are a little shorter. All the ten spines or horns end in a black polished bulb, the tip end of which is whitish, the bulb bearing several (5-7) conical setiferous tubercles. The spines on the sides of the body are small and short; not so long as or scarcely longer than the dorsal ones are thick. (Fig. 2.) On the thoracic segments those of the lowest row are much thicker, larger, and longer than those of the next (infraspiracular) row above. On abdominal segments 1 to 7 the dorsal, supraspiracular, and infraspiracular tubercles are all of the same shape and size, all moderately long acute, not tipped with black, and bearing from 7 to 8 sharp spinules; those of the lowest (infraspiracular) row a little longer than the supraspiracular ones.

The median spine on the eighth abdominal segment is fully twice as long and large as the dorsal ones on segments 1 to 7, blackish at the acute tip, with rather numerous stout spinules. On each side behind the median spine are two small low tubercles, as in *C. sepularis*. A stout conical smooth tubercle on segment 9, which is about one-third as long as the median one on the preceding segment with two similar spines on each side of it, though those of the lower row are a little larger and more spinose.

Suranal plate (fig. 2a) short and broad, rough on the surface, but unarmed (not so spiny as in *C. regalis*, that of *C. sepularis* being still more armed); a group of four or five minute conical setiferous reddish pink tubercles on each side, near the base, and a few minute ones along the edge; but it is much smoother than in *C. sepularis* and also than in *C. regalis*. Spiracles black, inclosing a large pale straw-yellow center. Body green, with reddish pink spines. Legs green; the mid-abdominal ones green with a blackish vertical shade, sometimes broken into two spots. In front of each abdominal spiracle is a narrow, oblique ascending black line. Anal legs with a few minute spinules.

*Food plant*.—The nature of the plant on which the species feeds is not stated by Burmeister.

*Geographical distribution*.—Canta galli, Brazil (L. Agassiz, Museum of Comp. Zoology, Thayer Expedition; collected by Doctor Teuscher); Brazil, not rare, chiefly found in the environs of Bahia; a variety, ♀, from Para (Boisduval); Novo Friburgo (Boisduval, Burmeister).

## CITHERONIA VOGLERI (Weyenburgh).

*Ceratocampa vogleri* WEYENBURGH, Period. Zool. Argent. III, p. 369. 1881.—KIRBY, Syn. Cat. Lep. Het. I, p. 744. 1892.

*Eucles leona* DRUCE, Proc. Zool. Soc. London, p. 500. 1890.

*Citheronia vogleri* SCHAUER, Amer. Lep., p. 21. Pl. III, fig. 2, ♂. 1892.

*Imago*.—1 ♂, 1 ♀. Antennae of ♂ much ciliated, the filiform extremity forming more than half their length. The shape of the wings much as in *C. magnifica*; fore wings acute, the outer edge very oblique; hind wings acute at the apex, subtriangular. Body and wings of a peculiar uniform umber brown, with two diverging cream-white lines on the thoracic disc. Fore wings with two unequal spots at base, and three rows of long oval cream-colored spots, eight in the extradiscal row, two subcostal, two median, and two near the inner edge; two minute scarlet discal spots, inside of which is a large semioval cream spot, and beyond two triangular marks.

Hind wings with a large oblong bright conspicuous scarlet spot; the wings at base yellow-ocher, extending half way along the inner edge; a row of narrow triangular yellow spots along the margin.

Beneath, more yellow than above; a large and conspicuous scarlet discal spot on the wings of both pairs. At the base of the fore and hind wings are Indian-red spots. Abdomen umber, with a lateral yellow line, and cross-bands of reddish-ocherous, which do not meet above; ♀ marked like the ♂.

Expanse of the fore wings, ♂ 77 mm.; ♀ 104 mm. Length of one fore wing, ♂ 37 mm.; ♀ 54 mm. Breadth of one fore wing, ♂ 16 mm.; ♀ 25 mm. Length of one hind wing, ♂ 22 mm.; ♀ 35 mm. Breadth of one hind wing, ♂ 16 mm.; ♀ 25 mm.

*Geographical range*—Cordova, Argentina (Weyenburgh); Brooklyn Museum, Neumoegen collection.

## CITHERONIA SEPULCRALIS Grote and Robinson.

Pl. XX, fig. 16, ♂.

*Citheronia sepulcralis* GROTE and ROBINSON, Proc. Ent. Soc. Phil., IV, p. 222. April, 1865. Annals Lyceum Nat. Hist. New York, VIII, p. 382. Pl. 12, figs. 2, 3, ♂. Oct., 1866.—KIRBY, Syn. Cat. Lep. Het. I, p. 743. 1892.

## Larva.

Pls. XIV, LV, figs. 4, 4a, 4b.

Grote and Robinson, Annals Lyceum Nat. Hist., N. Y., VIII, p. 382. 1866.

Edwards, II, Ent. Amer., III, p. 168. Dec., 1887.

Packard, 5th Rep. U. S. Ent. Comm., Ins. Inj. Forest Trees, p. 772. 1890.

*Imago*.—2 ♂.—Body, wings, and legs uniformly dark gray with a lilac tinge, nearly of the hue of *C. regalis* between the orange-colored veins of that species. No yellow or orange marks; thorax and abdomen with no yellow or orange spots; head as in *C. regalis*; ♂ antennae with 17 pairs of double pectinations, *C. regalis* having two more pairs (19); palpi large and stout, a little more so than in *C. regalis* and *azteca*.

Fore wings with two pale pink spots at the base, one just behind the base of the median vein; the other behind the origin of the vein at the base of the wing next to the pink patch on the body at the insertion of the hind wings. (Pl. LVIII, figs. 4, 4a.) A moderately large dusky discal spot centered by an irregular crescent-shaped orange-red mark. No other markings.

Hind wings pale pink on the basal half or two-thirds of the wing, and the pink area incloses the discal discoloration, which is smaller than on the fore wings.

Under side of the fore wings pink from the base along the middle to the discal spot; the veins are as above, but a little paler, and more lilac. The fore legs are not spined; the fore tibial epiphysis differs in shape from that of *C. regalis*, being a little longer and less acute. (Pl. XXXVI, fig. 23, 23a.) Hind ♂ tibiae with a stout spine on the inside, the outer one vestigial. They are a little larger than in *C. regalis*. The genitalia (Pl. LX, fig. 3a, 3b,) differ

from those of *C. regalis* in the upper claspers being a little narrower and longer, while the lower pair (harpes) are very different, being much smaller and thinner, rather broader, stouter, and flatter below, less far apart and the tips less upcurved. The suranal plate is much wider at base. I have not yet seen the female in any collection, as it is very rare.

Expanse of the fore wings, ♂ 75 mm.; length of one fore wing, ♂ 35 mm.; breadth of one fore wing, ♂ 15 mm.; length of a hind wing ♂ 22 mm.; breadth of a hind wing, ♂ 15 mm.

The uniformly dark lilac-gray hue of this species is noteworthy. Structurally it differs from *C. regalis* in having fewer pectinations and in the palpi being apparently stouter, and in the shape of the fore tibial epiphysis, as well as in the very different shape of the ♂ genital armature.

This species, whether we consider the larva or imago, is the most highly modified of any of the genus, forming the type of a distinct section of the genus. In this connection it is noteworthy that the species is, so far as yet known, confined to the Atlantic coast of North America (Map IX), and this suggests that it is the most recently evolved species of the genus, whose center of origin was evidently the eastern forest region of South America.

*Egg.* Slightly flattened spherical-oval; the surface very finely pitted. Length 2.3 mm.; diameter 1.9 mm.

Received from Mr. William Dearden, Lonsdale, R. I., June 20; the larvae hatched July 1-2.

*Larva.—Stage I.*—Length 6.5 mm. Body rather slender. Head smooth, shining jet-black. Prothoracic segment large, receiving the head, which is partly concealed or hooded by it. Three pairs of large, dull black, rather long dorsal spines, each spine ending in a large flattened bulb, which ends in a long slender process; those of the prothorax a little shorter than the two hinder pairs, and extended out horizontally over the head. Second and third thoracic and abdominal segments 1-4 deep honey-yellow, the rest of the abdomen black, but irregularly spotted or mottled with wax-yellow on the sides.

Abdominal segments 1 to 7 with small irregular dorsal spines each bearing four tines, the upper bent horizontally; those on the seventh and eighth segments larger and more erect. The median one on the eighth and ninth abdominal segments much larger and higher, but with no bulbous enlargements.

On abdominal segments 1 to 4 in front of each dorsal and lateral spine is an irregular angular black spot, the lateral one much the larger and squarish. The suranal plate flat. The plates on the anal legs are spiny, with long stiff setae. Thoracic and abdominal legs black, all large and long.

July 12. Length now 9 mm., about ready to molt. The prothoracic segment is yellow, like the two behind, except the large oblong black dorsal plate giving rise to the two horns. The body is black on abdominal segments 5 to the end, though paler than before.

*Stage II.*—Just molted, July 13, 9 a. m. Length 10 mm. Head jet-black. The body is now dull wax-yellow, with dusky hues. A wax-yellow longitudinal band on the middle of the prothorax, and the anterior edge of the second and third thoracic segments are dusky. An interrupted dusky or umber-brown broad subdorsal band. Abdominal legs concolorous with the band. The larger spines are a little larger, the bulbs a little smaller in proportion. All the spines are black throughout, and the metathoracic horns are a little longer than the body is thick. Prothoracic horns about two-thirds as long as the four behind.

On the outside of the abdominal legs above the planta is a rough jet-black plate. The middle of the anal legs umber-brown. A subdorsal and a lateral row of black spots.

It somewhat reminds one, as regards the color, of a late wax-yellow stage of *E. imperialis*.

*Stage III.*—Molted for the second time (in New York) July 23. Length 15 mm. Head dull pitchy reddish yellow. The three pairs of large dorsal spines now longer than before; one-quarter longer than the body is thick, but still retaining the bulbous horned expansions at the end; they are much larger in proportion than the dorsal abdominal ones. The colors are faded and too indistinct to describe.

I once found a nearly full-grown caterpillar of this rare moth on the pitch-pine at Brunswick, Me., August 5, which lived in confinement until the 17th of the month. The following year a younger one occurred on the white pine during the second week in August.

"*Young larva*.—Length, 11 mm. Head large, pale brick-red. Body pale green, tubercles straw-yellow, green at base. The dorsal tubercles all nearly the same size, except the prothoracic ones, which are nearly one-half as large as the mesothoracic; those on mesothoracic, metathoracic, and first abdominal segments of equal size and only a little larger than those on the other abdominal segments. Eighth pair of abdominal ones larger than the others and nearly as large as the thoracic ones. The long, slender spines on the thoracic segments black, those on the abdominal in part black, especially the inner ones.

"*Larva, probably before the last molt*.—Head full, rounded, retractile in the prothorax, nearly concolorous with the body, being corneous. Body uniformly horn-brown, the color of old dark parchment, with no green shade about it. On each thoracic segment a long, slender warted subdorsal spine, the prothoracic pair projecting a little in front and smaller and one-third shorter than the other four, which are recurved. The six long thoracic spines are succeeded by a dorsal row of short stout smooth acute spines with a dull orange-red tint. Each spine has two or three small slender dark spinules and about three terminal unequal spinules. On the side of each thoracic segment are two short conical tubercles with a few stiff spinules. On the abdomen above the spiracles is a row of dull orange-reddish smooth spines, and below a row of much slenderer spines, which are spinulated much like the dorsal thoracic ones. These spines are situated on the folds of the lateral ridge of the body. Below this subspiracular row of spines is a subventral row of small spines on the three thoracic segments, and which are large and long on the first and second abdominal segments and on the last three segments. On the middle of the eighth segment is a large straight dorsal stiff spine nearly as large as the larger thoracic ones. At its base behind are two minute spines. On the segment behind (ninth) is a median stout spine, making the middle one of a transverse row of seven spines on that segment. Supraanal plate flat, obtuse, variously and obtusely tuberculated, especially around the edges, as are the sides of the large anal legs and the sides of the prolegs, which are very retractile. The spiracles are large, black, and very conspicuous, the last pair larger than the others. There are also scattered smoky-black blotches, a row on the front edge of each segment and one at the base of the dorsal spines. Length, 50 mm. (2 inches). The larva of *septentrionalis* (of which Professor Riley has blown larvae of four stages) differs from that of *C. regalis* in the stage before the last molt in having only six spines on the anterior end and two pairs of straight spines on the end, those on the prothoracic segment longer in proportion than in *C. regalis*, and all ending in bulbous enlargements. In the mature larva all the spines are shorter and the spinules have shorter spines. Length 100 mm. (4 inches)." (Rep. Forest Insects, p. 772.)

The tubercles  $\frac{7}{7}$  are present in the fully grown larva on abdominal segment 8, and each bears two short fine setae.

*Geographical distribution*.—From southern Maine and New Hampshire to Georgia and Florida. Brunswick, Me. (Packard); Manchester, N. H. (F. H. Foster); Lawrence, Mass. (J. O. Treat); Lonsdale, R. I., June 20 (Dearden); Providence, end of June (G. Gray); New York City (Edwards, Grote); Pennsylvania; Georgia (Abbot); Jacksonville, Fla. (Mrs. Slosson). (See Map IX.)



## INDEX OF GENERA AND SPECIES.

Page.	Page.		
Adelocephala.....	61	Citheronia principalis.....	140
albolineata.....	76	regalis.....	130
anthomilis.....	87	septuleralis.....	145
bicolor.....	65	splendens.....	138
bisecta.....	75	vogleri.....	145
boisduvalii.....	83	consularis, Anisota.....	106
brevis.....	88	Crinodes.....	
cadmus.....	84	bellatrix.....	90
crocata.....	88	crocata, Adelocephala.....	88
heiligbrodtii.....	76	dissimilis, Anisota.....	116
högei.....	78	Eacles.....	116
isias.....	79	cacicus.....	126
jucunda.....	87	imperialis.....	119
montezuma.....	77	penelope.....	128
quadrilineata.....	74	heiligbrodtii, Adelocephala.....	76
subangulata.....	85	högei, Adelocephala.....	78
wardii.....	86	imperialis, Eacles.....	119
albolineata, Adelocephala.....	76	isias, Adelocephala.....	79
Anisota.....	96	jucunda, Adelocephala.....	87
consularis.....	106	laocoon, Citheronia.....	142
dissimilis.....	116	mexicana, Citheronia.....	138
rubricunda.....	111	molina, Syssphinx.....	92
senatoria.....	107	montezuma, Adelocephala.....	77
stigma.....	98	penelope, Eacles.....	128
suprema.....	115	petersii, Syssphinx.....	95
virginicensis.....	102	phoronea, Citheronia.....	141
anthomalis, Adelocephala.....	87	principalis, Citheronia.....	140
azteca, Citheronia.....	139	quadrilineata, Adelocephala.....	74
bellatrix, Crinodes.....	90	regalis, Citheronia.....	130
bicolor, Adelocephala.....	65	rubricunda, Anisota.....	111
bisecta, Adelocephala.....	75	senatoria, Anisota.....	107
boisduvalii, Adelocephala.....	83	sepuleralis, Citheronia.....	145
brevis, Adelocephala.....	88	splendens, Citheronia.....	138
brissotti, Citheronia.....	137	stigma, Anisota.....	98
cacicus, Eacles.....	126	subangulata, Adelocephala.....	85
cadmus, Adelocephala.....	84	suprema, Anisota.....	115
Citheronia.....	128	Syssphinx.....	91
azteca.....	139	molina.....	92
brissotti.....	137	? petersii.....	95
laocoon.....	142	virginicensis, Anisota.....	102
mexicana.....	138	vogleri, Citheronia.....	145
phoronea.....	141	wardii, Adelocephala.....	86



---

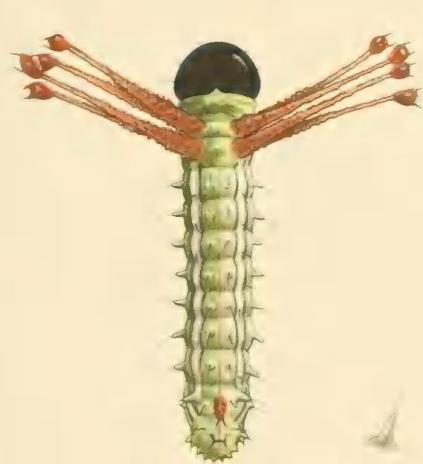
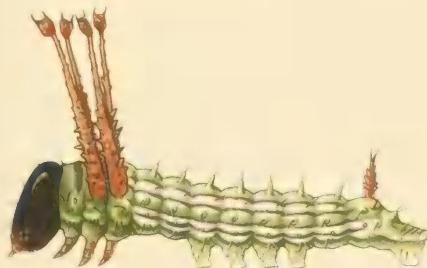
P L A T E S.

---

#### EXPLANATION OF PLATE I.

FIG. 1.—*1a*, *Adelocephala bicolor*, larva, stage I, enlarged; *1b*, tubercle *i* of an abdominal segment; *1c*, tubercle of infraspiracular series.

FIG. 2.—*2a*, The same, stage II. J. Bridgham, del. The hair line indicates the length of the specimen figured.





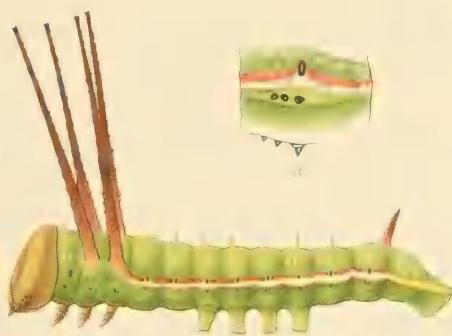
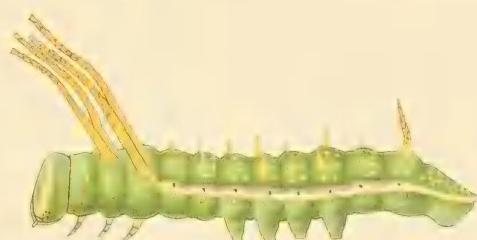
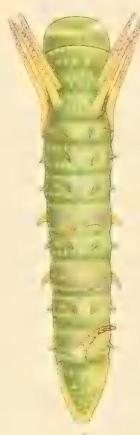
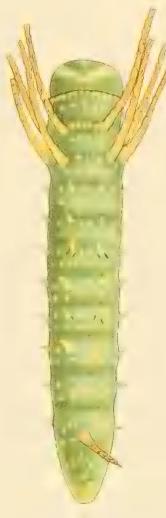


#### EXPLANATION OF PLATE II.

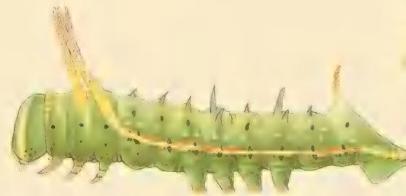
FIG. 1.—1a, *Adelocephala bicolor*, stage III.

FIG. 2.—2a, *Adelocephala bicolor*, stage IV.

FIG. 3.—3a, *Adelocephala bicolor*, stage V; 3b, dorsal tubercle on fourth and sixth abdominal segments, inside view; 3c, the same seen from the outside; 3d, the same, front view; 3e, the caudal horn; 3f, an abdominal segment, showing a portion of the red and white lateral line, and spiracle. J. Bridgham, del.



st.



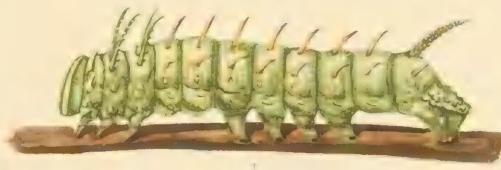
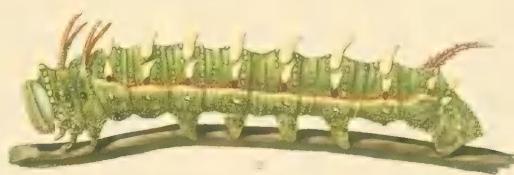
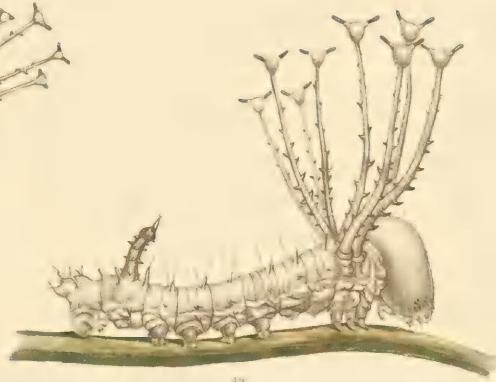
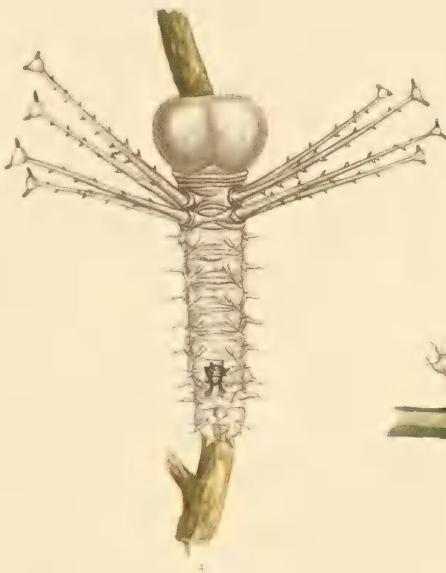




#### EXPLANATION OF PLATE III.

- FIG. 1.—Undetermined Larva of *Adeloccephala* from Brazil, natural size.  
FIG. 2.—Larva of *Adeloccephala isias*, last stage, San Antonio, Tex., natural size.  
FIG. 2a.—Larva of *Adeloccephala isias*, stage IV, Brownsville, Tex.  
FIG. 3.—Larva of *Adeloccephala isias*, Brownsville, Tex.  
FIG. 4—4a, *Syssphinx molina*, stage I, much enlarged.

L. H. Joutel, del.



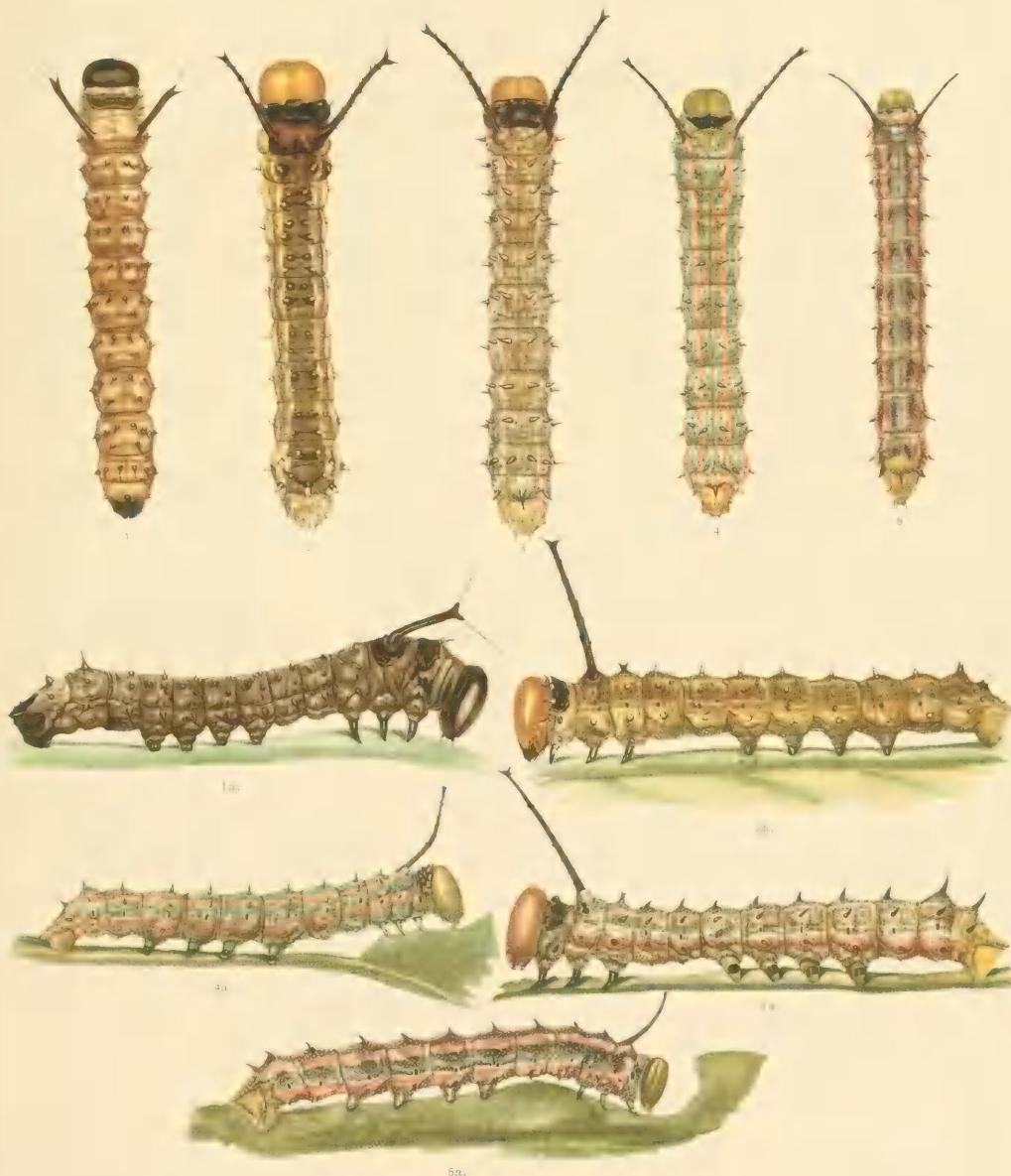




#### EXPLANATION OF PLATE IV.

- FIG. 1.—*Anisota virginiensis*, stage I, end of the first stage, much enlarged.  
FIG. 1a.—*Anisota virginiensis*, stage I, freshly hatched larva, much enlarged.  
FIG. 2.—*Anisota virginiensis*, stage II, larva having just molted, enlarged.  
FIG. 2a.—*Anisota virginiensis*, stage II, larva in middle of the stage, enlarged.  
FIG. 3.—3a, *Anisota virginiensis*, stage III, enlarged.  
FIG. 4.—4a, *Anisota virginiensis*, stage IV, enlarged.  
FIG. 5.—5a, *Anisota virginiensis*, stage V, last stage; natural size.

All drawn by L. H. Joutel.

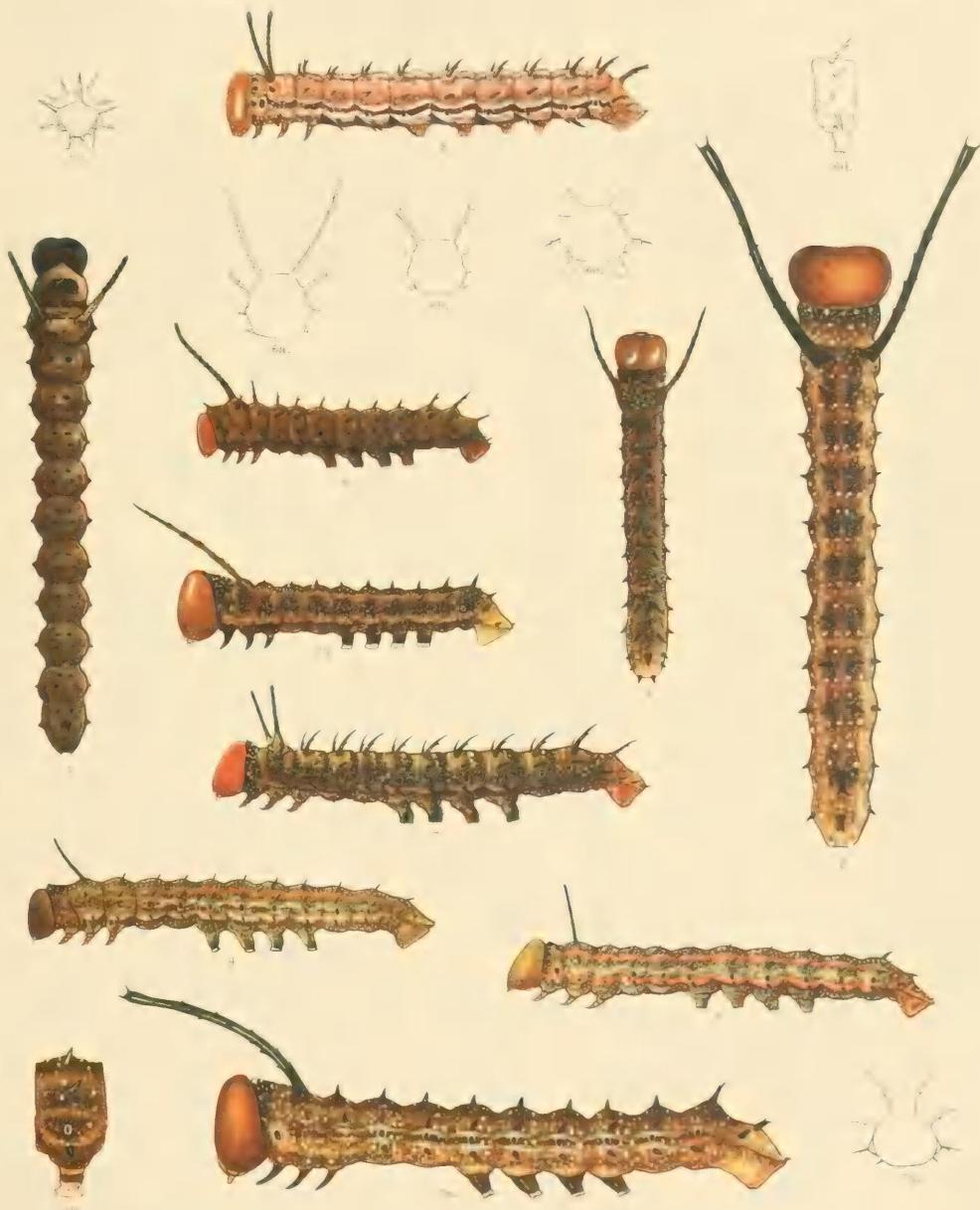






#### EXPLANATION OF PLATE V.

- FIG. 1.—*Anisota virginiana*, stage I., greatly enlarged.  
FIG. 2.—2a, *Anisota virginiana*, stage III., enlarged.  
FIG. 3.—3a, *Anisota virginiana*, stage III; end of the stage, enlarged.  
FIG. 4.—*Anisota virginiana*, stage IV., enlarged.  
FIG. 5.—*Anisota virginiana*, last stage, natural size.  
FIG. 6.—*Anisota stigma*, stage III.  
FIG. 6a.—Section through second thoracic; 6b, third; 6c, third abdominal; 6d, fourth abdominal; 6e, end of body, from rear.  
FIG. 7.—*Anisota stigma*, last stage.  
FIG. 7a.—*Anisota stigma*, section showing the spines. J. Bridgman, del.  
FIG. 8.—*Anisota consularis*, last stage, natural size. L. H. Joutel, del.

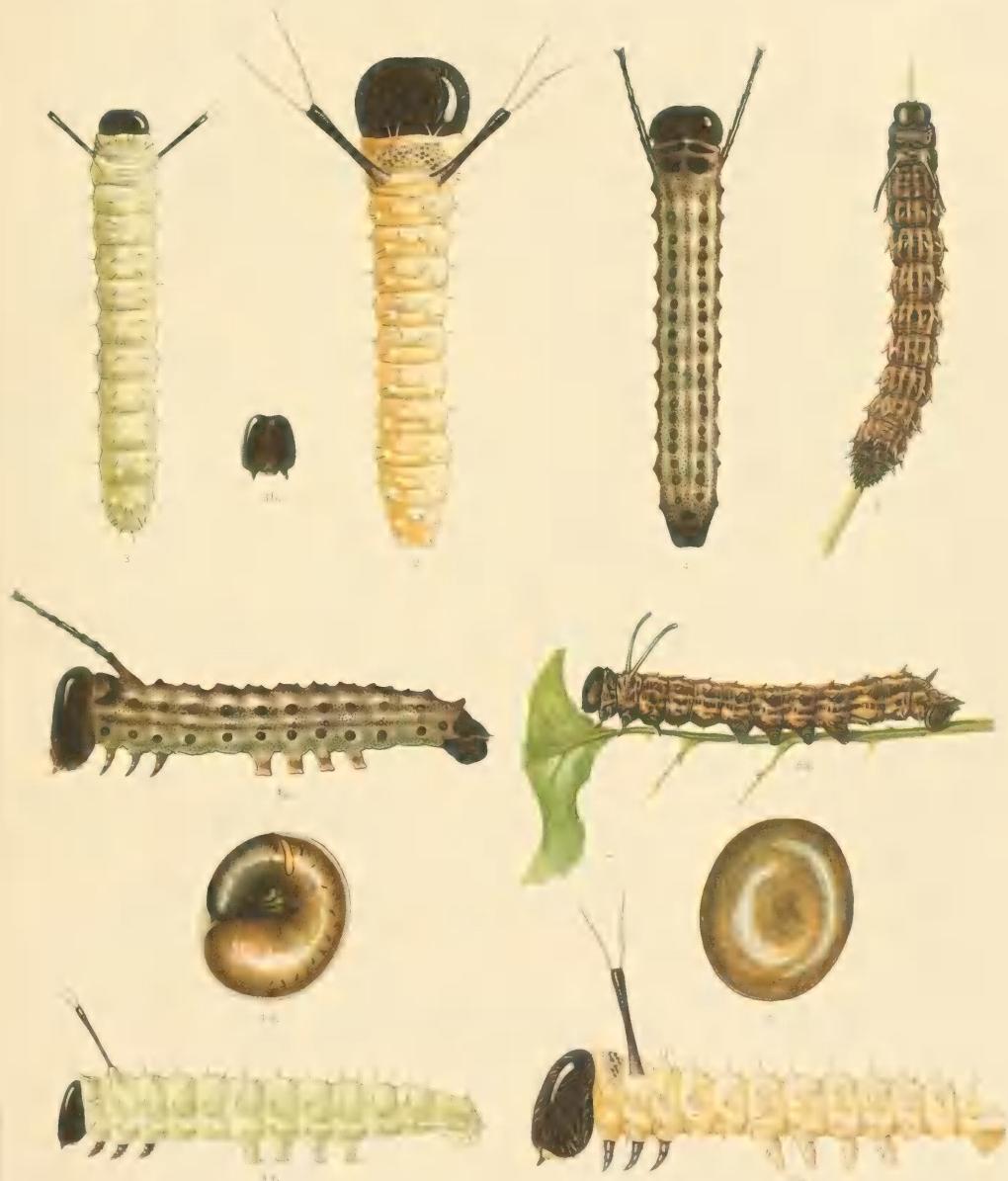
1-5. *Anisota virginiensis*; 6, 7. *A. stigma*. 8. *A. consularis*.





#### EXPLANATION OF PLATE VI.

- Fig. 1.—*Anisota senatoria*, egg, much enlarged, usual color; 1a, one hour before the larva hatches; July 13.  
Fig. 2.—2a, *Anisota senatoria*, stage I, much enlarged.  
Fig. 3.—3a, *Anisota senatoria*, stage I, end of the stage, much enlarged.  
Fig. 4.—4a, *Anisota senatoria*, stage III, enlarged. J. Bridgman, del.  
Fig. 5.—5a, *Anisota senatoria*, last stage (V), natural size. L. H. Jouret, del.







#### EXPLANATION OF PLATE VII.

- FIG. 1.—1*a*, *Anisota rubieunda*, larva freshly hatched; stage I; enlarged. Joutel *del.*  
FIG. 1*b*.—Freshly hatched larva, natural size. Bridgman *del.*  
FIG. 2.—2*a*, Freshly hatched larva, stage II; enlarged. Joutel *del.*  
FIG. 3.—3*a*, Freshly hatched larva, stage IV; enlarged. Joutel *del.*  
FIG. 4.—4*a*, Freshly hatched larva, last stage (V); enlarged. Joutel *del.*  
FIG. 5.—5*a*, Adult larvae.



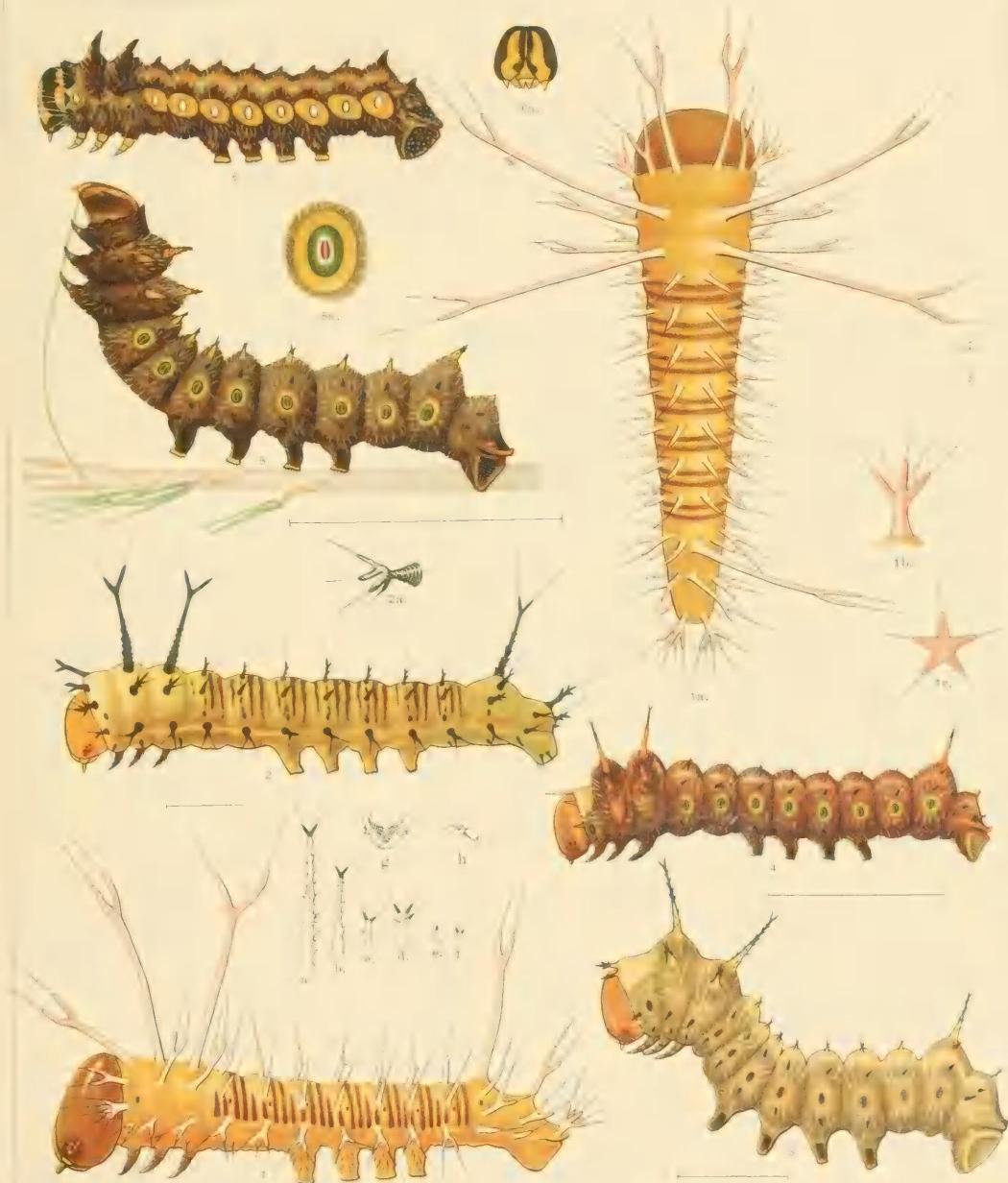




#### EXPLANATION TO PLATE VIII.

- FIG. 1.—*Eacles imperialis*, stage I, much enlarged.  
FIG. 2.—*Eacles imperialis*, stage II, much enlarged.  
FIG. 3.—*Eacles imperialis*, stage III, much enlarged.  
FIG. 4.—*Eacles imperialis*, stage IV, enlarged.  
FIG. 5.—*Eacles imperialis*, stage V, enlarged.  
FIG. 6.—*Eacles imperialis*, stage VI, natural size.  
FIG. 6a.—Front of head of dark form.

J. Bridgman, del.



*Eacles imperialis*, stages I-VI.





#### EXPLANATION OF PLATE IX.

FIG. 1.—1a, *Eubosca imperialis*, stage IV, green form, natural size; 1b, prothoracic segment; 1c, dorsal tubercles of second thoracic segment; 1d, third abdominal segment; 1e, eighth to tenth abdominal segments.  
FIG. 2.—2a, *Eubosca imperialis*, fully grown, green form; 2b, front of head; 2c, first thoracic segment; 2d, third abdominal segment; 2e, eighth to tenth segments.

J. Bridgman, del.



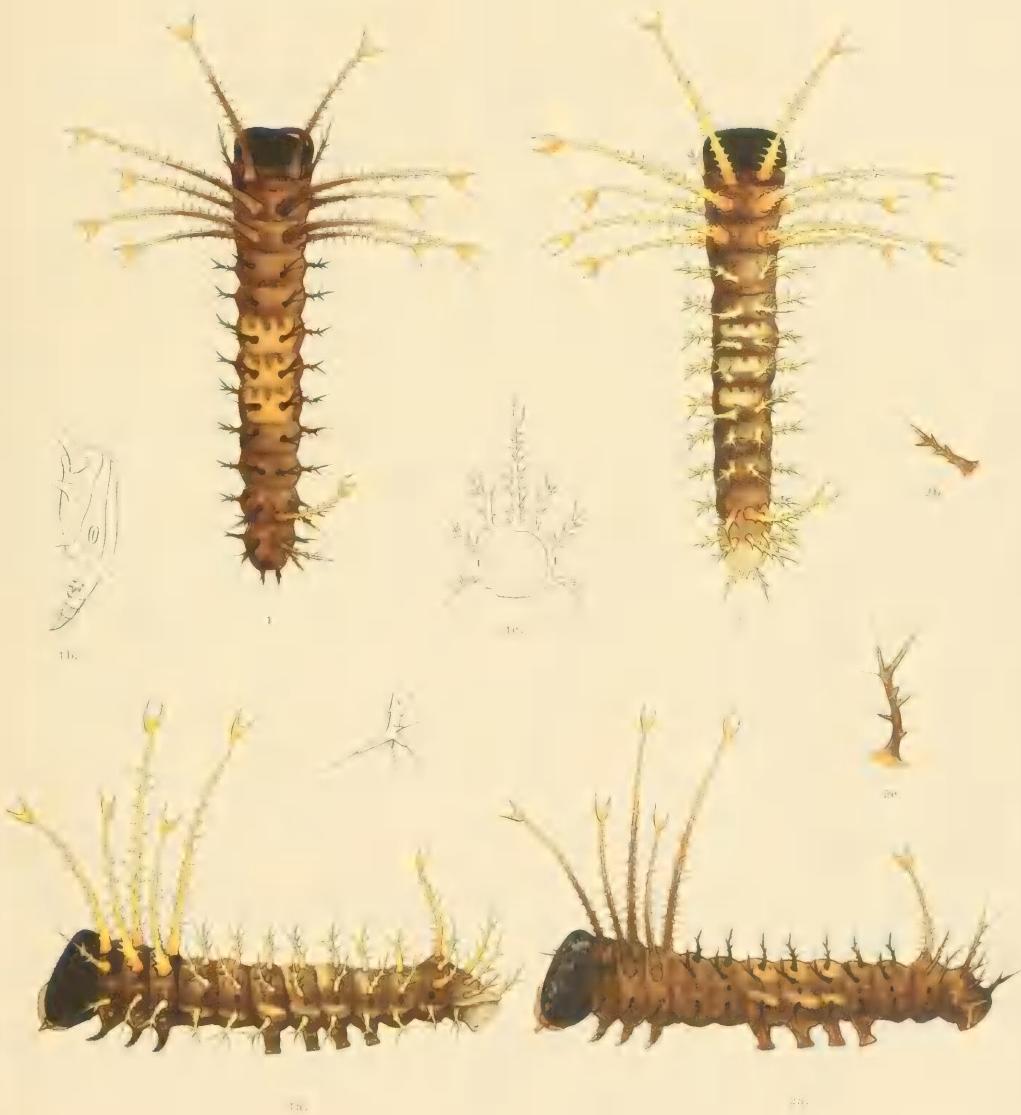
FACIES IMPERIALIS





#### EXPLANATION OF PLATE X.

- FIG. 1.—*1a*, *Citheronia regalis*, stage 1, freshly hatched, much enlarged; *1b*, prothoracic segment; *1c*, section of eighth abdominal segment; *1d*, tubercle of infraspinaular series.  
FIG. 2.—*2a*, *Citheronia regalis*, near end of stage 1; *2b*, subdorsal tubercle of first thoracic segment; *2c*, one of dorsal row, same segment. J. Bridgman del.

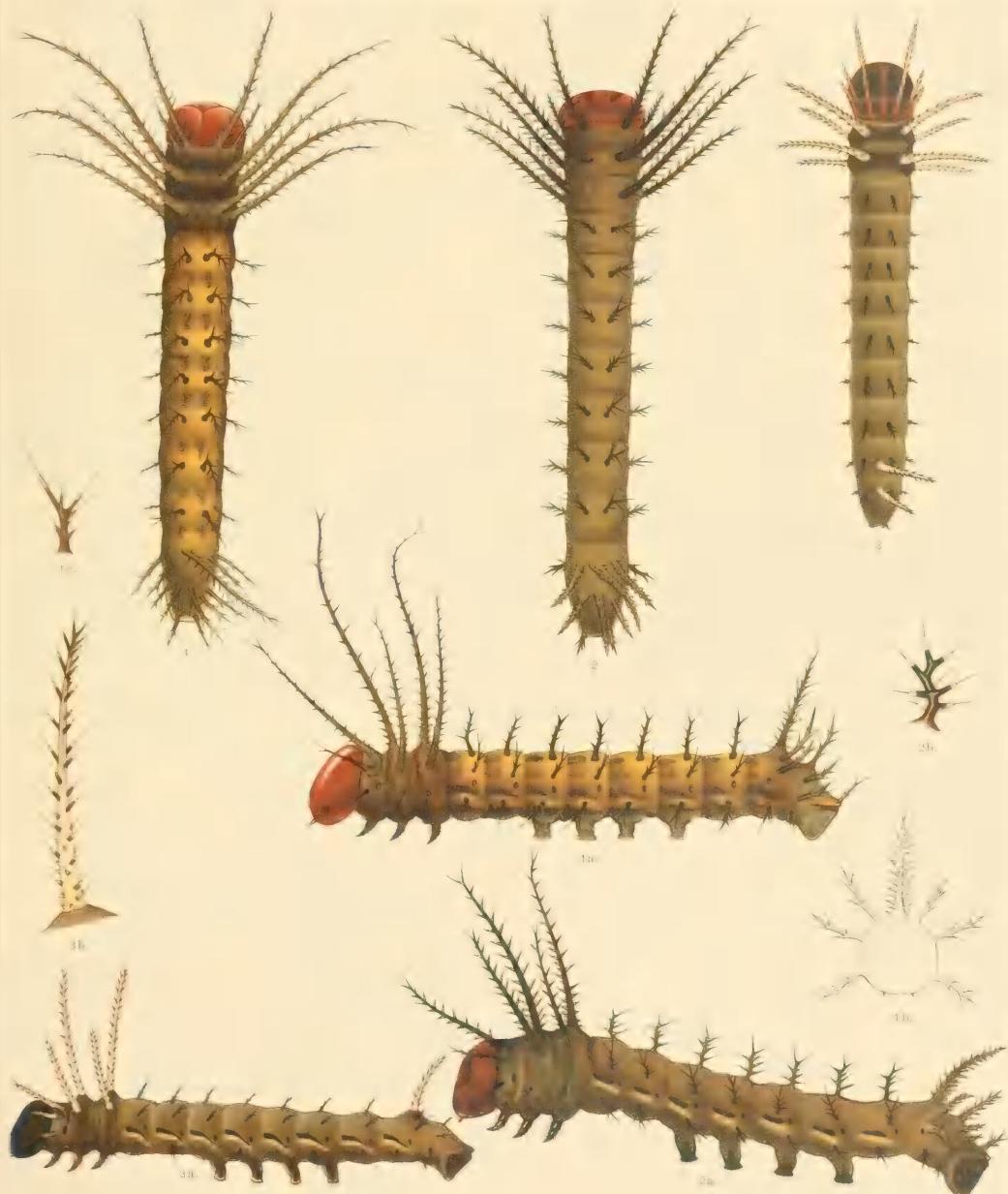






#### EXPLANATION OF PLATE XI.

- FIG. 1.—1a, *Citheronia regalis*, stage II; much enlarged; 1b, section of eighth abdominal segment; 1c, abdominal spine of subdorsal series.  
FIG. 2.—2a, *Citheronia regalis*, stage III; enlarged; 2b, a dorsal abdominal spine.  
FIG. 3.—3a, *Citheronia regalis*, stage IV; natural size; 3b, dorsal spine of second thoracic segment.  
J. Bridgman, del.



Citheronia regalis.





#### EXPLANATION OF PLATE XII.

FIG. 1.—*1a*, *Citheronia regalis*, stage III; *1b*, front view of head and thoracic segments with the horns; enlarged.  
FIG. 2.—*Citheronia regalis*, stage IV, natural size; *2a*, suranal plate; *2b*, anal leg.  
J. Bridgman, del.







#### EXPLANATION OF PLATE XIII.

FIG. 1.—1a, *Citheronia regalis*, stage IV, natural size; 1b, spine of infraspinaular row; 1c, a subdorsal spine of an abdominal segment; 1d, dorsal spine of same segment; 1e, anal leg; 1f, caudal horn.

FIG. 2.—2a, *Citheronia regalis*, stage V and last, natural size (under fed); 2b-2c, spines; 2e, a thoracic leg; 2f, section through third abdominal segment.

FIG. 3.—*Citheronia regalis*, slightly larger than natural size; 3a, dorsal horn; 3b, subdorsal horn. (Not a satisfactory figure.)

J. Bridgman, del.



CITHERONIA REGALIS.





#### EXPLANATION OF PLATE XIV.

FIG. 1.—1a, *Citheronia sepulcralis*, stage I, much enlarged.

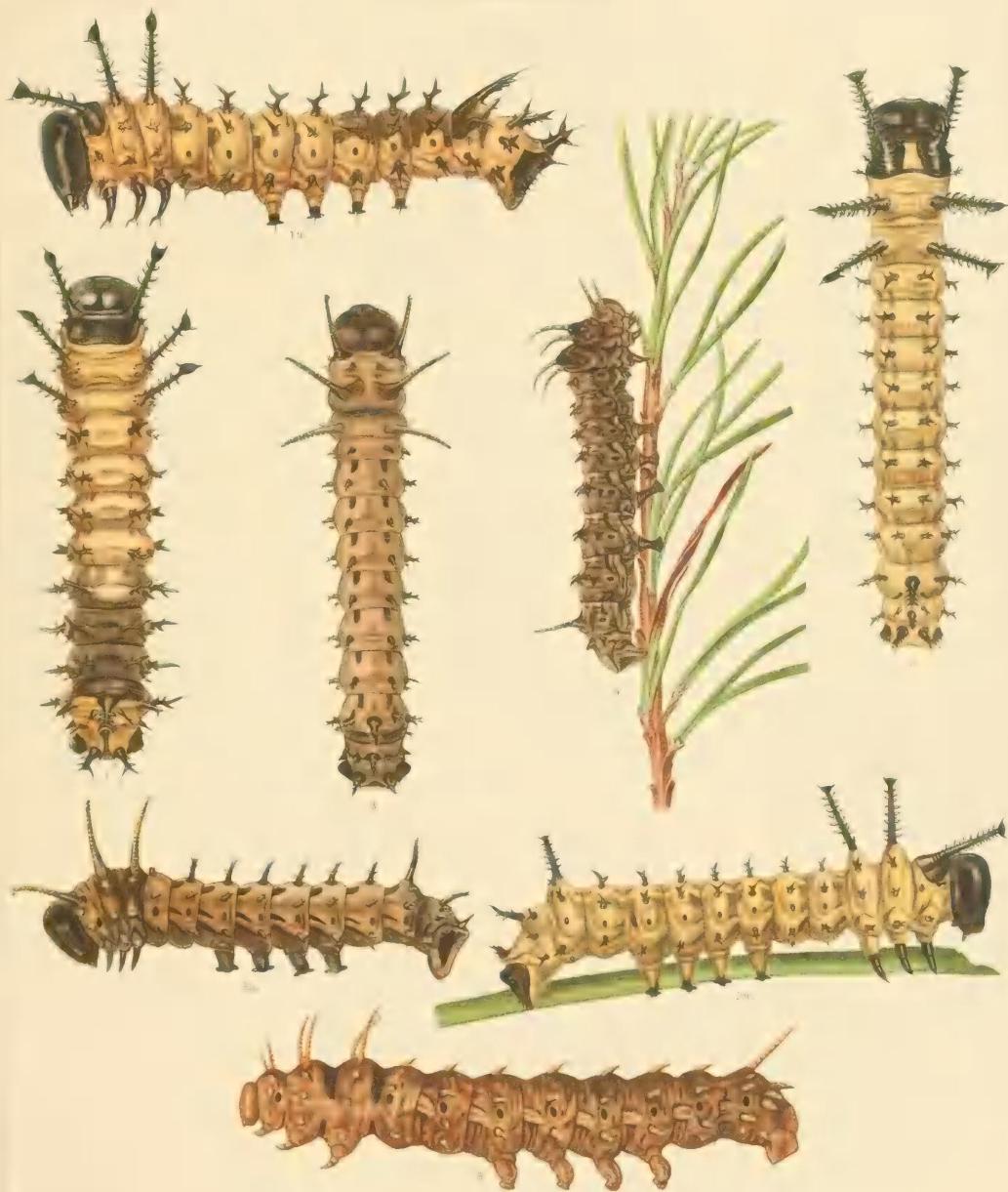
FIG. 2.—2a, *Citheronia sepulcralis*, stage II, much enlarged.

FIG. 3.—3a, *Citheronia sepulcralis*, stage III, enlarged.

FIG. 4.—*Citheronia sepulcralis*, last stage, natural size. E. Shoemaker, del.

FIG. 5.—*Citheronia sepulcralis*, last stage. Drawn by J. Bridgham from a blown specimen in H. Edwards's collection; a little larger than life.

Figs. 1-3, drawn from life, by L. H. Joutel.







## EXPLANATION OF PLATE XV.

FIG. 1.—*Citheronia splendens*, natural size.

FIG. 2.—*Citheronia laevocornis*, natural size.

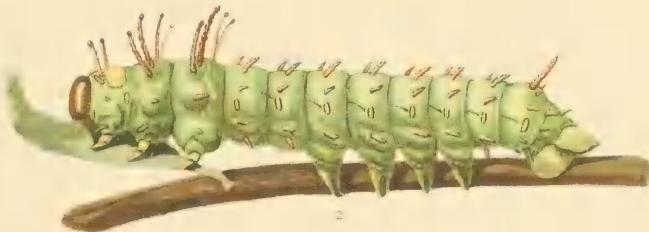
FIG. 3.—*Eacles imperialis* var.

All drawn from blown larvae, by L. H. Joutel.

FIG. 4.—Outline of egg of *Citheronia regalis*, greatly enlarged; 4a, the sculpturing on the shell. NOTE.—The areas in 4a should have been drawn more polygonal.



1



2



3



4





#### EXPLANATION OF PLATE XVI.

- FIG. 1.—Larva of *Citheronia phoronea*, natural size.  
FIG. 2.—Larva of *Citheronia laocoon* (ixion) natural size.  
FIG. 3.—Larva of “*Citheronia regalis*,” natural size, 3A, head in front; 3B, *a*, mandible outer side; *b*, inner side; *c*, ocelli.  
FIG. 4.—Larva of *Syssphinx molina*, natural size.  
FIG. 5.—Larva of *Diphnia consularis*; 5*a*, body seen from end; 5*b*, a spine enlarged.  
FIG. 6.—Pupa of the same, natural size; 6A, head of the same, from beneath.

A copy from Burmeister's Atlas, of Plate XIX.



1.



2.



3.

3A.



4.



6



5.



5a.

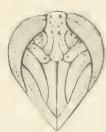
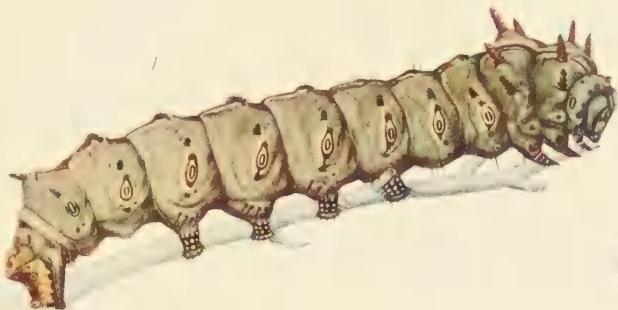




#### EXPLANATION OF PLATE XVII.

- FIG. 1.—Larva of *Eudes penelope*, natural size.  
FIG. 2.—Larva of *Eudes caucicus*, natural size; 2A, head from in front; 2B, labium and one maxilla.  
FIG. 3.—*Adelocephala wardii*, natural size.  
FIG. 4.—*Citheronia principalis*, natural size.  
FIG. 5.—Pupa of *Eudes caucicus*, 5A, head from beneath; 5B, end of body, ♂. *a*, sexual opening; *b*, anus.  
FIG. 6.—Pupa of *Citheronia principalis*, natural size.  
FIG. 7.—Under side of head of pupa of *Diciphia consularis*.

A copy of Plate XX of Burmeister's Atlas.







#### EXPLANATION OF PLATE XVIII.

- FIG. 1.—*Citheronia laocoon*, ♂.  
FIG. 2.—*Citheronia splendens*, ♂; 2 a, ♀.  
FIG. 3.—*Citheronia azteca*, ♂.  
FIG. 4.—*Citheronia mexicana*, ♂.  
FIG. 5.—*Eacles imperialis*, ♂.



5. *EACLES IMPERIALIS.*

1-4. *CITHERONIA.*





#### EXPLANATION OF PLATE XIX.

- FIG. 1.—*Adelocephalia albolineata*, ♀.  
FIG. 2.—*Adelocephalia subangulata*, ♂.  
FIG. 3.—*Adelocephalia bicolor*, ♂.  
FIG. 4.—*Adelocephalia hogei*, ♂.  
FIG. 5.—*Adelocephalia heiligbrodtii*, ♂.  
FIG. 6.—*Adelocephalia montezuma*, ♂.  
FIG. 7.—*Anisota supremus*, ♂. The moth is too green; the fore wing should be of a rich, warm brown.  
FIG. 7a.—*Anisota supremus*, ♀.  
FIG. 8.—*Citheronia principalis*, ♀.  
FIG. 9.—*Citheronia laeviorum*, ♀.



1-6. ADELOCEPHALA.

7-7A. ANISOTA.

8-9. CITHERONIA.





#### EXPLANATION OF PLATE XX.

- FIG. 1.—*Anisota virginiensis*, ♀.  
FIG. 2.—*Anisota virginiensis*, ♂.  
FIG. 3.—*Anisota virginiensis*, ♀.  
FIG. 4.—*Anisota stigma*, ♂.  
FIG. 5.—*Anisota stigma*, ♂.  
FIG. 6.—*Anisota stigma*, ♀.  
FIG. 7.—*Anisota stigma*, ♂.  
FIG. 8.—*Anisota stigma*, ♀. This example has no spots on wings of one side; loaned by Mr. Joutel.  
FIG. 9.—*Anisota stigma*, ♂.  
FIG. 10.—*Anisota senatoria*, ♀.  
FIG. 11.—*Anisota senatoria*, ♀.  
FIG. 12.—*Anisota senatoria*, ♂.  
FIG. 13.—*Adelocerphala bisecta*, ♂.  
FIG. 14.—*Adelocerphala bisecta*, ♀.  
FIG. 15.—*Anisota rubricunda*, ♂.  
FIG. 15a.—*Anisota rubricunda*, ♂.  
FIG. 15b.—*Anisota rubricunda*, ♀.  
FIG. 16.—*Citheronia sepulcralis*, ♂. The hue is too green; the moth is of a warm purplish gray brown.



ANISOTA AND CITHERONIA SEPULCRALIS.





#### EXPLANATION OF PLATE XXI.

FIG. 1.—*Citheronia regalis*, fully grown, green form (the black spots on the yellow of the anal legs should be removed).

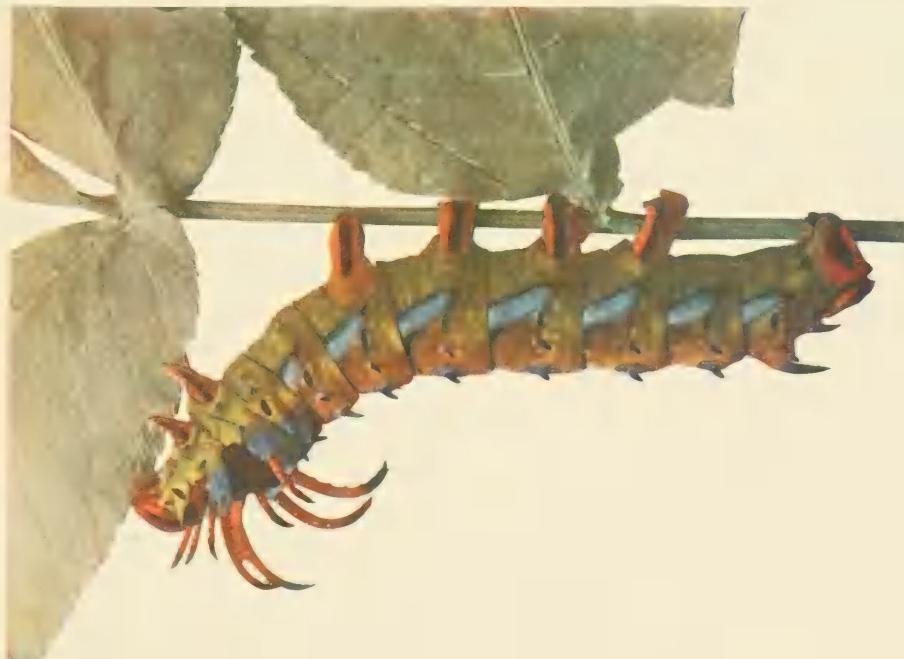
FIG. 2.—*Citheronia regalis*, fully grown, green and orange form.

After colored photographs by A. Hyatt Verrill.

NOTE.—In all the figures of *Citheronia regalis*, the caterpillar should be represented as feeding back downward with the body suspended by the very long mid-abdominal legs.



CITHERONIA REGALIS.



1. GREEN-ORANGE FORM.

2. GREEN FORM.





#### EXPLANATION OF PLATE XXII.

FIG. 1.—*Citheronia regalis*, blue and orange form.

FIG. 2.—Pink form, stage IV.

After photographs by A. Hyatt Verrill.



1. BLUE AND ORANGE FORM.



2. PINK FORM.

*CITHERONIA REGALIS.*



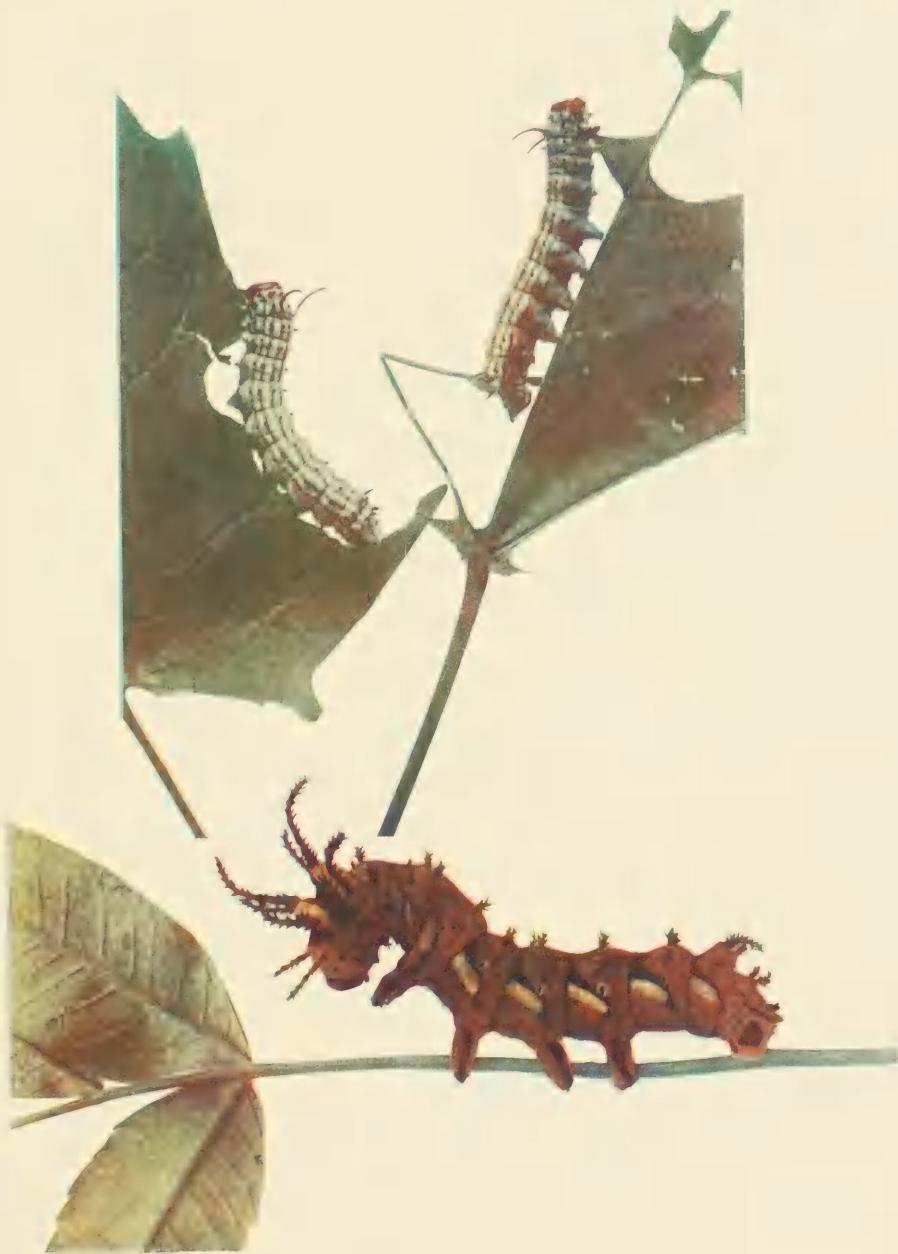


#### EXPLANATION OF PLATE XXIII.

FIG. 1.—*Citheronia regalis*, stage IV, natural size; brown form.

FIG. 2.—*Anisota rubricunda*, last stage, natural size.

From colored photographs by A. Hyatt Verrill.



2. ANISOTAPE RUBICUNDA.

1. CITHERONIA REGALIS, STAGE 4, BROWN FORM.





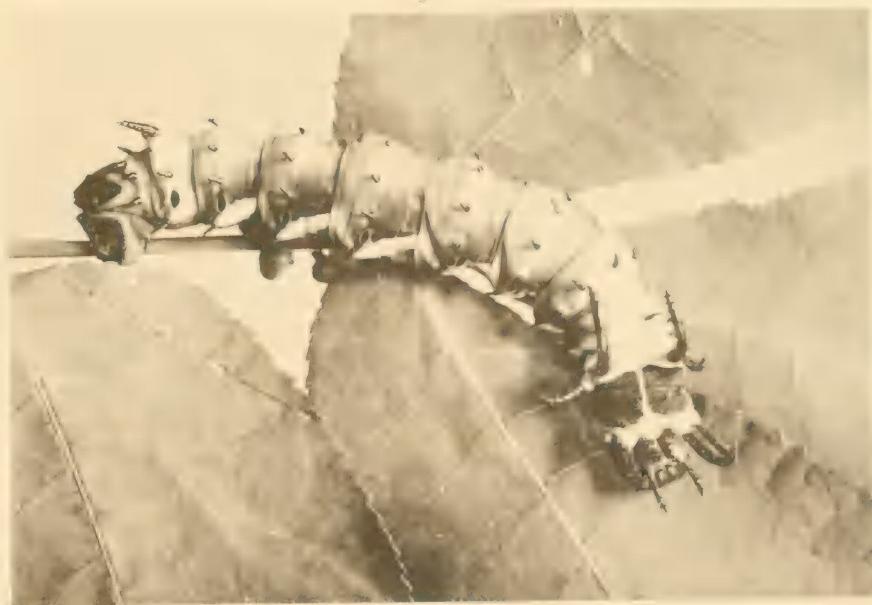
#### EXPLANATION OF PLATE XXIV.

FIG. 1.—*Citheronia regalis*, green form; last stage; in its resting attitude, though the head should hang downward.  
FIG. 2.—The same (green form), dorsal view.

From photographs by A. Hyatt Verrill.



Fig. 1



A. S. CARLTON

Fig. 1 C. REGALIS (green form) last stage, resting attitude.  
Fig. 2 C. REGALIS (green form) last stage, dorsal view





#### EXPLANATION OF PLATE XXV.

FIG. 1.—*Citheronia regalis*, green form, in feeding attitude.

FIG. 2.—*Citheronia regalis*, blue form, resting attitude.

The two photographs should be side by side with the heads of the caterpillars uppermost, as it hangs attached by its abdominal legs.

A. Hyatt Verrill, photo.



A. S. CAMPBELL ART CO.

C. REGALIS  
C. REGALIS





#### EXPLANATION OF PLATE XXVI.

FIG. 1.—*Citheronia regalis*, pink form, stage IV.

FIG. 2.—Brown form, stage IV.

A. Hyatt Verrill, photo.



Fig.

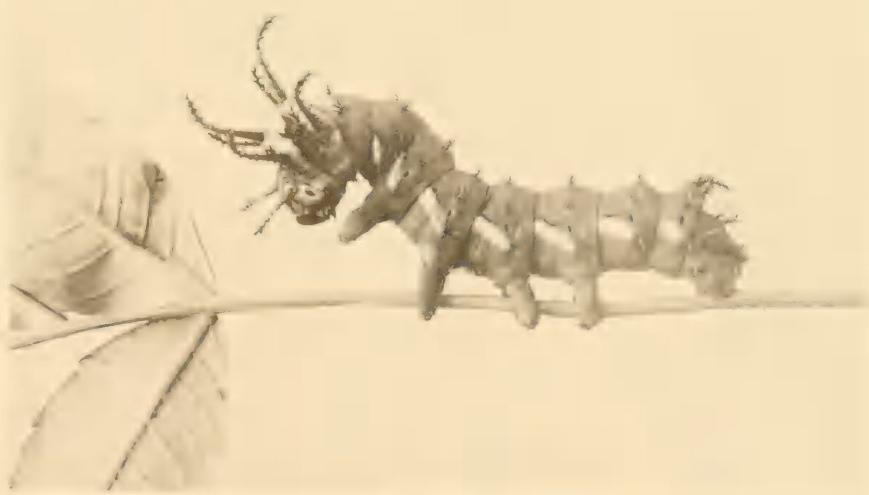


Fig. C. REGAL S. (pink form) stage

Fig. C. REGAL S. (brown form).





#### EXPLANATION OF PLATE XXVII.

- FIG. 1.—*Eacles imperialis*, eggs, with freshly hatched larvae, natural size.  
FIG. 2.—*Eacles imperialis*, eggs, with freshly hatched larvae, the same enlarged.  
FIG. 3.—*Eacles imperialis*, last stage, showing the long hairs, natural size.  
A. Hyatt Verrill, photo.



Fig. D. — *E. IMPERIALIS*.  
Fig. E. — *E. IMPERIALIS*.  
Fig. F. — *E. IMPERIALIS*.





#### EXPLANATION OF PLATE XXVIII.

FIG. 1.—*Eacles imperialis*, stages II and IV.

FIG. 2.—*Eacles imperialis*, stage III.

FIG. 3.—*Eacles imperialis*, last stage.

From photographs by A. Hyatt Verrill.



Fig. 1



Fig.



Fig. 3

Fig. 1. E. MEEBLESI. — Plate 34.  
Fig. 2. E. IMPERIALIS. — Plate 35.  
Fig. 3. E. MEEBLESI. — Plate 36.





#### EXPLANATION OF PLATE XXIX.

- FIG. 1.—*Anisota virginicensis*, last stage.  
FIG. 2.—*Anisota virginicensis*, stage II.  
FIG. 3.—*Anisota virginicensis*, stage III. All of natural size.  
From photographs by A. Hyatt Verrill.



Fig. 3



Fig. 2



Fig. 1

Fig. 1. *A. VIRGINIENSIS* full fed  
Fig. 2. *A. VIRGINIENSIS* stage 2  
Fig. 3. *A. VIRGINIENSIS* stage 3





#### EXPLANATION OF PLATE XXX.

FIG. 1.—*Anisota stigma*, stage II.

FIG. 2.—*Anisota stigma*, stage III.

FIG. 3.—*Anisota stigma*, stage IV. All of natural size.

From photographs by A. Hyatt Verrill.



Fig. 1.

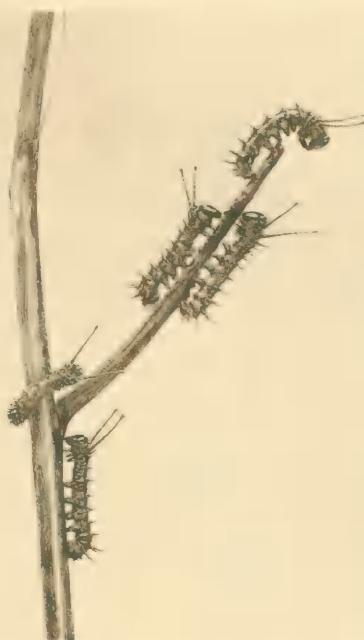


Fig. 2.

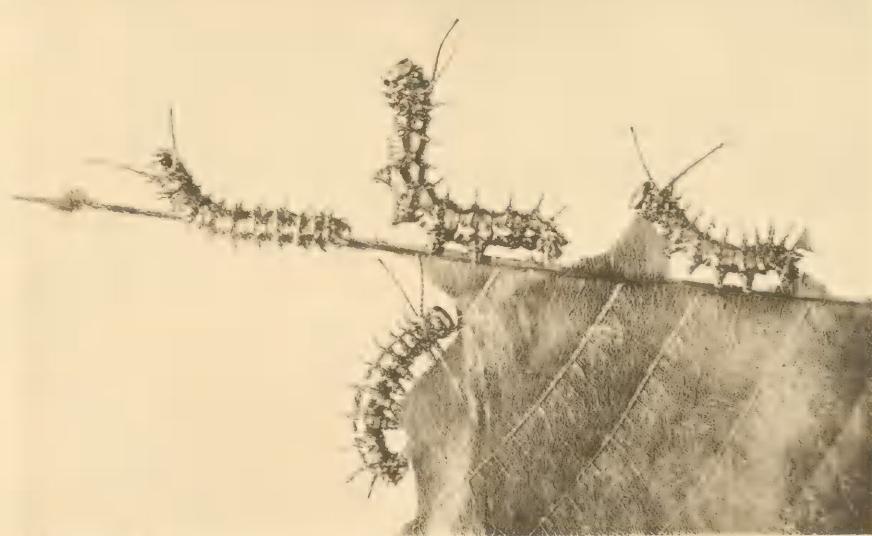


Fig. 3.

Fig. 1. ANISOTA STIGMA

Fig. 2. ANISOTA STIGMA

Fig. 3. ANISOTA STIGMA





#### EXPLANATION OF PLATE XXXI.

FIG. 1.—*Anisota stigma*, last stage; also a caterpillar of *Jauassa lignicolor*.

FIG. 2.—*Anisota senatoria*, stage II.

FIG. 3.—*Anisota senatoria*, stage III.

FIG. 4.—*Anisota senatoria*, stage IV.

From photographs by A. Hyatt Verrill.



Fig. 1

Fig. 2



Fig. 3

Fig. 4

A. S. CAMPBELL ART CO.

Fig. 1. ANISOTA STIGMA last stage also Janassa lignicolar

Fig. 2. ANISOTA SENATORIA stage 2

Fig. 3. ANISOTA SENATORIA stage 3

Fig. 4. ANISOTA SENATORIA stage 4





#### EXPLANATION OF PLATE XXXII.

- Fig. 1.—*Anisota senatoria*, last stage, natural size.  
Fig. 2.—*Anisota rubricunda*, stages II and III, natural size.  
Fig. 3.—*Anisota rubricunda*, stage IV, natural size.  
From photographs by A. Hyatt Verrill.

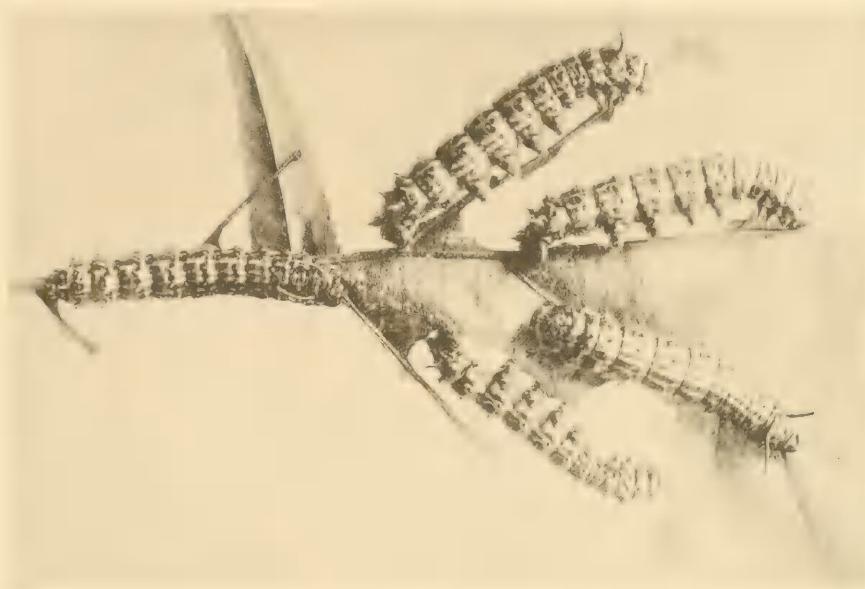


Fig. 1



Fig. 2

Fig. 3

- Fig. 1. *ANISOTA SENATORIA* last stage  
Fig. 2. *ANISOTA RUBICUNDA* stages 2 and 3  
Fig. 3. *ANISOTA RUBICUNDA* last stage





#### EXPLANATION OF PLATE XXXIII.

- FIG. 1.—*Adelocephala istia*, ♂ and ♀.  
FIG. 2.—*Adelocephala wardii*, ♂.  
FIG. 3.—*Adelocephala högelii*, ♂.  
FIG. 4.—*Syssphinx molina*, ♂ and ♀.



B. S. CAMPBELL ART CO., ELIZ. N. J.

Fig. 4.

Fig. 1. *ADELOCEPHALA ISIAS* (male and female)

Fig. 2. *ADELOCEPHALA WARDI*

Fig. 3. *A. HOGEI*

Fig. 4. *SYSSPHINX MOLINA* (male and female)





#### EXPLANATION OF PLATE XXXIV.

- FIG. 1.—*Ceratomia amyntor*, middle of stage I, much enlarged.  
FIG. 1a.—*Ceratomia amyntor*, end of stage I, enlarged. The body should be paler, more transparent.  
FIG. 2.—2a. *Ceratomia amyntor*, stage II, at end, enlarged. The body should be paler, more transparent.  
FIG. 3.—3a. *Ceratomia amyntor*, stage III, about to molt, enlarged.  
FIG. 4.—4a. *Ceratomia amyntor*, stage V and last, natural size.  
FIG. 5.—*Ceratomia undulosa*, stage I, much enlarged.  
All drawn by L. H. Joutel.  
FIG. 6.—*Ceratomia amyntor*, stage I, portion of surface of caudal horn, showing the glandular setæ, and the tubercles giving rise to them; some of the setæ twice as large as the others.  
FIG. 6a.—One lobe of caudal horn, stage I, armed with glandular setæ and showing the large bulbous terminal seta.  
FIG. 6b.—The two tubercles *i* and *ii* arising from the main tubercle of the second thoracic segment, stage I.  
FIG. 6c.—The same on the third thoracic segment. Author, del.



Ceratomia amyntor.





#### EXPLANATION OF PLATE XXXV.

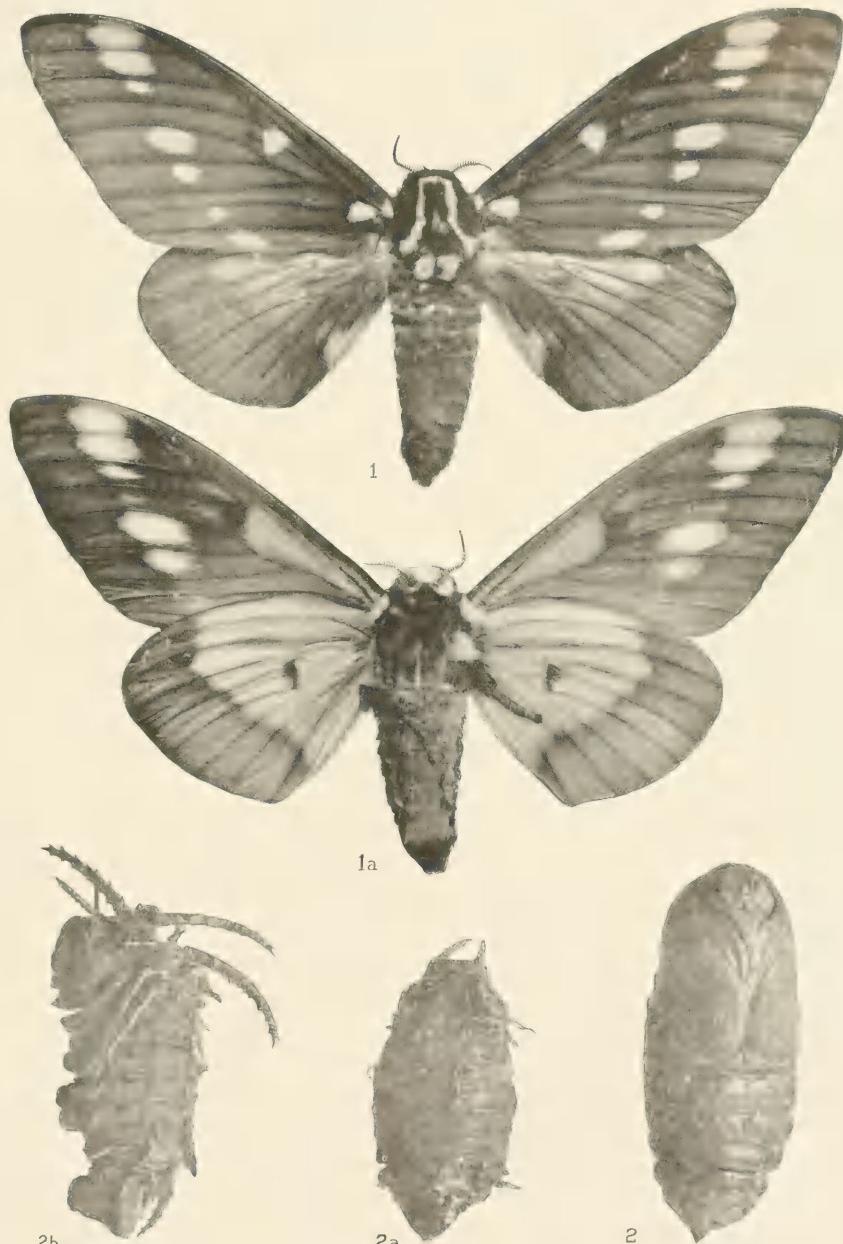
FIG. 1.—*Citheronia regalis*, ♂.

FIG. 1a.—*Citheronia regalis*, ♀, natural size.

FIG. 2.—*Citheronia regalis*, pupa, natural size.

FIG. 2a, 2b?—*Citheronia regalis*, pupa partly concealed by the cast larval skin.

From a photograph by A. Hyatt Verrill.



CITHERONIA REGALIS





#### EXPLANATION OF PLATE XXXVI.

- FIG. 1.—*Adelocephalia bicolor*, head denuded.  
FIG. 2.—*Anisota virginensis*, head denuded.  
FIG. 3.—*Anisota rubricunda*, head denuded.  
FIG. 4.—*Eacles imperialis*, head denuded.  
FIG. 5.—*Citheronia regalis*, head denuded.  
FIG. 6.—*Cressonia juglandis*, head denuded.  
FIG. 7.—*Marumba modesta*, head denuded.  
FIG. 8.—*Cressonia juglandis*, part of ♂ antenna, seen from above; 8a, from beneath.  
FIG. 9.—*Citheronia regalis*, part of antennae, from beneath.  
FIG. 10.—*Anisota rubricunda*, palpus; the same denuded, more enlarged.  
FIG. 11.—*Eacles imperialis*, palpus, denuded.  
FIG. 12.—Fore tibial appendage of *Adelocephalia sabangulata*, ♂; t, tibia; ts, tibial spur.  
FIG. 13.—Fore tibial appendage of *Adelocephalia montezuma*, ♂.  
FIG. 14.—Fore tibial appendage of *Adelocephalia bicolor*, ♂.  
FIG. 15.—Fore tibial appendage of *Adelocephalia albolineata*, ♀.  
FIG. 16.—Fore tibial appendage of *Sapphoia molina*, ♂.  
FIG. 17.—Fore tibial appendage of *Anisota virginensis*, ♂.  
FIG. 18.—Fore tibial appendage of *Anisota stigma*, ♂; sp, spine.  
FIG. 19.—Fore tibial appendage of *Anisota senatoria*, ♂.  
FIG. 20.—Fore tibial appendage of *Anisota rubricunda*, ♂; 20a, the same from the other side.  
FIG. 21.—Fore tibial appendage of *Eacles imperialis*.  
FIG. 22.—Fore tibial appendage of *Citheronia regalis*; 22a, the same from the other side.  
FIG. 23.—Fore tibial appendage of *Citheronia sepulcralis*, ♂; 23a, the same from the inside.  
FIG. 24.—Fore tibial spur of *Adelocephalia högei*, ♂.

Head (denuded); tibial epiphysis, etc. of Sphingicampinae, etc.





#### EXPLANATION OF PLATE XXXVII.

- Fig. 1.—*Adelocepha bisecta*, venation of fore wing; 1a, hind wing.  
Fig. 2.—*Adelocepha'a albolineata*, venation of fore wing; 2a, hind wing.  
Fig. 3.—*Adelocepha montezuma*, venation of fore wing; 3a, hind wing.







#### EXPLANATION OF PLATE XXXVIII.

- FIG. 1.—*Adelocephala subangulata*, ♂, venation of fore wing; 1a, of hind wing.  
FIG. 2.—*Adelocephala heliobrodtii*, ♂, venation of fore wing; 2a, of hind wing.  
FIG. 3.—*Adelocephala wardii*, venation of fore wing; 3a, of hind wing.







#### EXPLANATION OF PLATE XXXIX.

- FIG. 1.—*Adelocephala stigma*, ♂, venation of fore wing; 1a, hind wing.  
FIG. 2.—*Adelocephala virginensis*, ♂, venation of fore wing; 2a, hind wing.  
FIG. 3.—*Adelocephala senatoria*, ♂, venation of fore wing; 3a, hind wing.  
FIG. 4.—*Adelocephala* —————, venation of fore wing; 4a, hind wing.  
FIG. 5.—*Adelocephala* —————, venation of fore wing; 5a, hind wing.  
FIG. 6.—*Adelocephala* —————, venation of fore wing; 6a, hind wing.

### Venation of Anisota.





#### EXPLANATION OF PLATE XL.

FIG. 1.—*Adelocephala subangulata*, genital armature; side view of end of the abdomen; 1a, suranal plate and its terminal forks; 1b, side view of the harpes (*lcl*), penis, and suranal plate; 1c, harpes and penis, from beneath; 1d, harpes and penis.

FIG. 2.—*Adelocephala bicolor*, genital armature, suranal plate, from above; 2a, a clasper; 2b, side view of suranal plate, penis, and penis sheath.

FIG. 3.—*Adelocephala heiligbrodtii*, genital armature, seen from above; 3a, side view of clasper; 3b, genitals, seen from beneath, *s'* knoblike; 3c, the same side view showing plainly the relations of the penis to its sheath, the dentate-divided end of the suranal plate, and the external clasper.

*Lettering of the figures.*—*cl*, clasper; *lcl*, harpes; *p*, penis; *p'*, penis sheath; *s*, suranal plate; *s'*, specialized, often toothed end of the suranal plate; VIII, IX, X, 8th-10th abdominal segment.







#### EXPLANATION OF PLATE XLI.

- FIG. 1.—*Adeloccephala bisecta*, genital armature; *cl*, clasper; *s*, specialized, toothed end of suranal plate; *p*, penis; *p'*, penis sheath.
- FIG. 2.—*Syssphinx molina*, genital armature, side view, showing penis; *2d*, end view of the same, showing the clasper and doubly mucronate suranal plate.
- FIG. 3.—*Anisota virginensis*, deeply forked suranal plate, below which is the penis and its sheath.
- FIG. 4.—*Anisota stigma*, dorsal view of genital armature, showing the deeply divided, specialized end of the suranal plate; *4a*, the same seen from beneath; *4b*, side view of the same.
- FIG. 5a.—*Anisota senatoria*, genital armature, clasper; *5b*, side view of the armature.
- FIG. 6.—*Anisota rubricunda*, deeply bilobed end of suranal plate (*s''*); *6a*, inner view, showing the penis and its sheath; *6b*, the same from beneath; *s'*, the specialized bilobed extremity of the suranal plate.
- FIG. 7.—*Eacles imperialis*, side view of clasper; *7a*, suranal plate from above; *7b*, genital armature seen from the side, *pl*, pleural membrane; *7c*, a minute adjunct of the penis sheath.
- FIG. 8.—Portion of male antenna of *Eacles imperialis*.

NOTE.—Lettering as on Plate XL.



FIG. 1.

Packard, del.

4

A. HOEN &amp; CO., LITH., BALTIMORE.

Genital armature of *Adelocephala*, *Syssphinx*, *Anisota*, *Eacles*.





#### EXPLANATION OF PLATE XLII.

FIG. 1.—*Ceratomia amyntor*, stage I, highly magnified.

FIG. 2.—*Ceratomia amyntor*, head and four trunk segments, stage II, magnified; 2a, end of the stage (14 mm. long); 2b, end of the body, showing the caudal horn, and sp, suranal plate; a, anal leg.

FIG. 3.—*Pionias myops*, caudal horn in last stage; 3a, end of the tip, from above and from the extreme of the tip.



Author del.

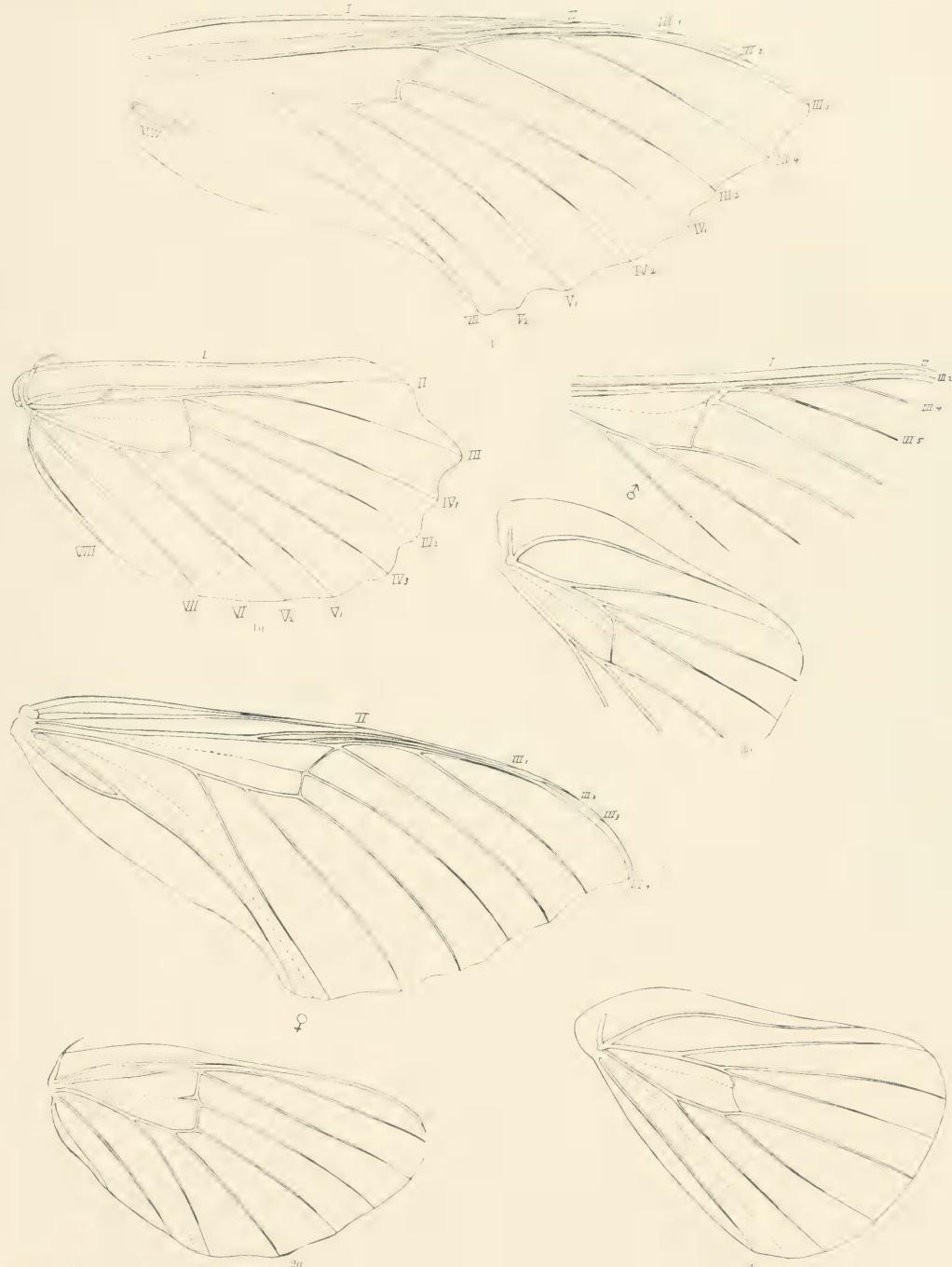
LARVA OF CERATOMIA AMYNTOR, STAGES 1, 2, ETC.





#### EXPLANATION OF PLATE XLIII.

- FIG. 1.—*Cressonia juglandis*, venation of fore wing; 1a, hind wing.  
FIG. 2.—*Marumba modesta*, ♀, venation of fore wing; 2a, hind wing.  
FIG. 3.—*Anisota senatoria*, ♂, venation of fore wing; 3a, hind wing.  
FIG. 4.—*Anisota dissimilis*, ♀, venation of hind wing. (See for fore wing Pl. LVII.)

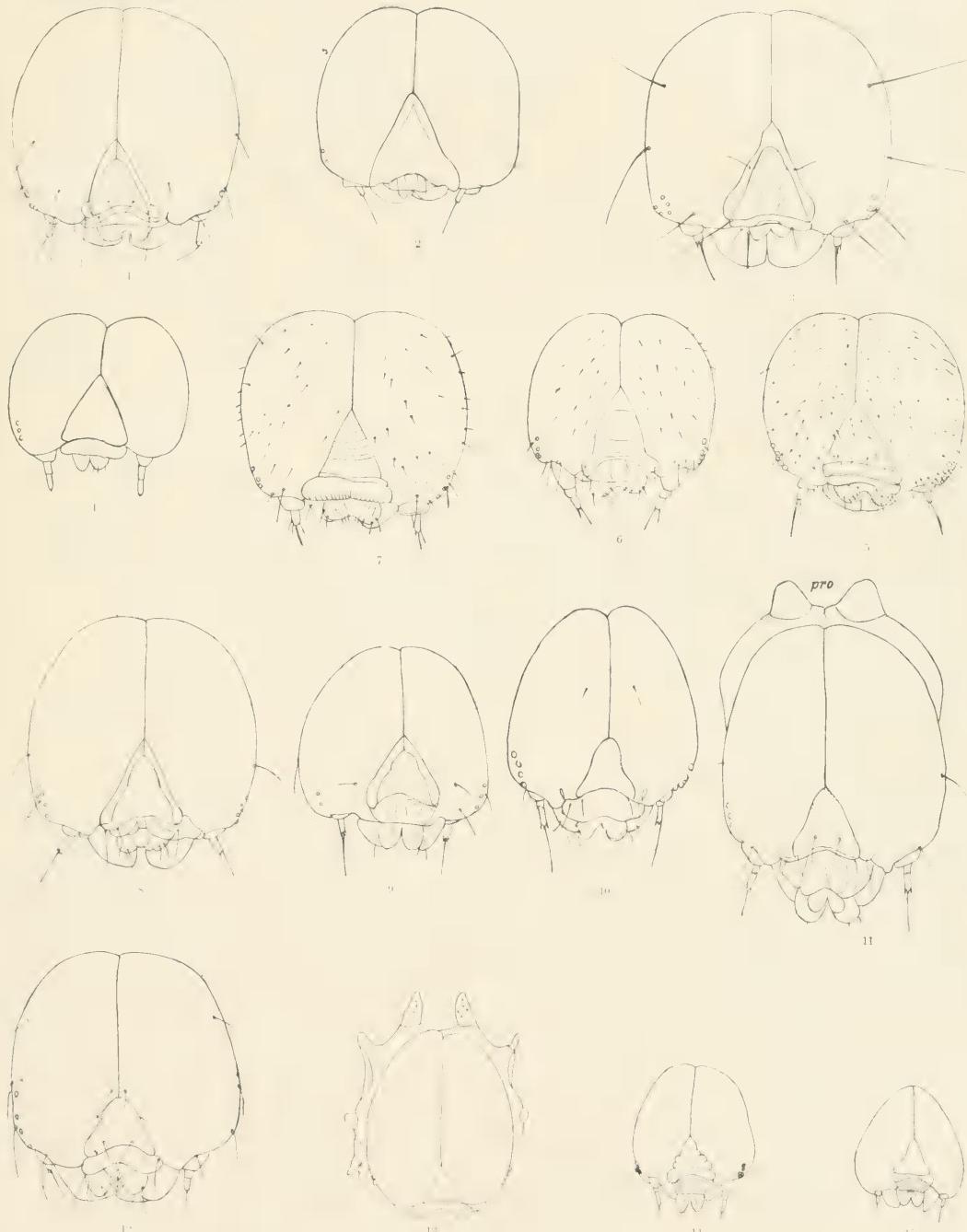






#### EXPLANATION OF PLATE XLIV.

- FIG. 1.—Head of a noctuid larva, allied to *Apatela?* seen from in front.  
FIG. 2.—*Ichthyura americana*, head, seen from in front.  
FIG. 3.—*Datana ministra*, head, seen from in front.  
FIG. 4.—*Apatelodes torrefacta*, head, seen from in front.  
FIG. 5.—*Bombyx mori*, last stage, head, seen from in front.  
FIG. 6.—*Endromis versicolora*, head, seen from in front.  
FIG. 7.—*Brahmaea japonica*, head, seen from front.  
FIG. 8.—*Lophodonta angulosa*, head, seen from in front.  
FIG. 9.—*Synnerista allifrons*, head, seen from in front.  
FIG. 10.—*Heterocampa binudata*, stage III, head, seen from in front.  
FIG. 11.—*Heterocampa guttivitta*, head, seen from in front.  
FIG. 12.—*Macrurocampa marthesia*, head, seen from in front.  
FIG. 13.—*Adelocephalia* sp. Brazil. Seen from in front.  
FIG. 14.—*Adelocephalia isias*. Texas. Seen from in front.  
FIG. 15.—*Paeonia myops*. Seen from in front.



Author del.

12

HEADS OF SYMBOMBYCINE AND SYSSPHINGINE LARVÆ, ETC.

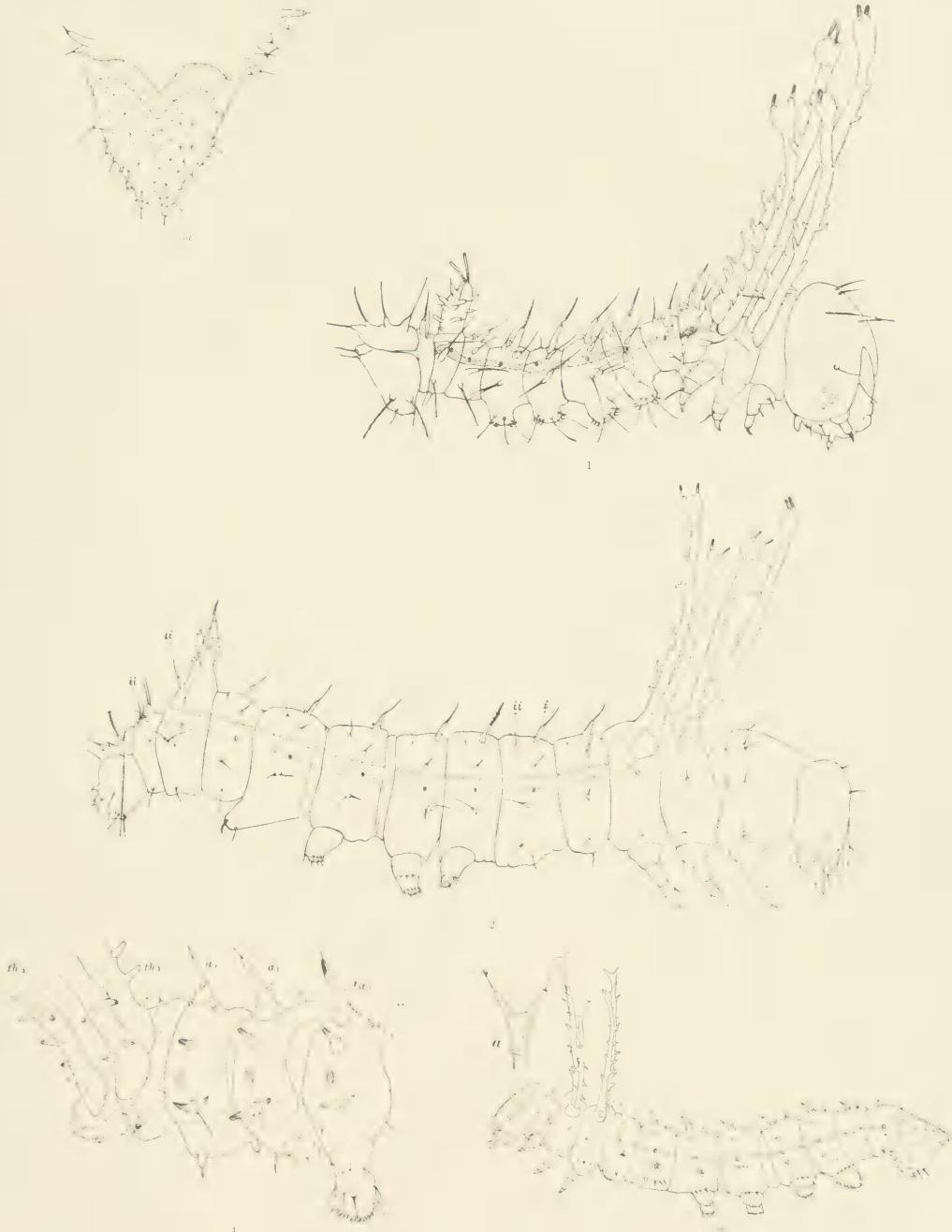
15





#### EXPLANATION OF PLATE XLV.

- FIG. 1.—*Adeloccephala bicolor*, larva, stage I, much magnified.  
FIG. 2.—*Adeloccephala bicolor*, end of stage I.  
FIG. 3.—*Adeloccephala bicolor*, stage II, the caudal horn not shown, having been diseased and bent down; *a*, end of second thoracic horn.  
FIG. 4.—*Adeloccephala bicolor*, stage III, showing the armature of the two hinder thoracic and first three abdominal segments; the subdorsal tubercle (*iii*); *a'*, tubercle *i*; *ii*; second dorsal tubercle of third abdominal segment.



Author del.

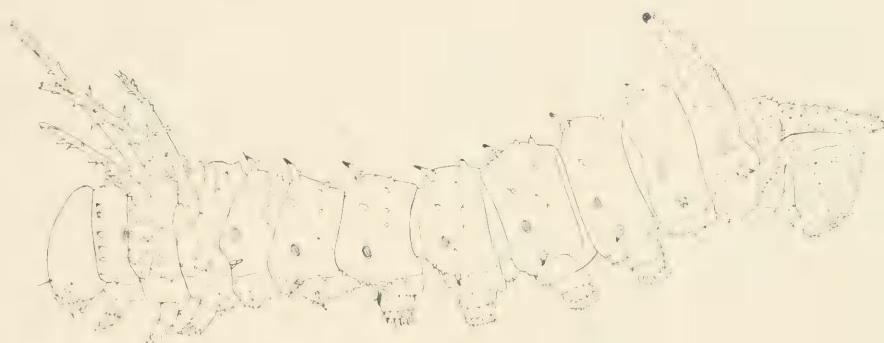
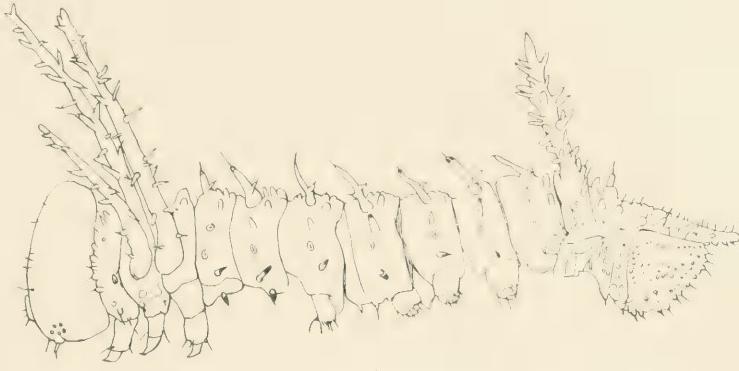
LARVA OF *ADELOCEPHALA BICOLOR*, STAGES I-III.





#### EXPLANATION OF PLATE XLVI.

- FIG. 1.—*Adelocephalia bicolor*, stage III, much enlarged.  
FIG. 2.—*Adelocephalia bicolor*, stage IV, much enlarged.  
FIG. 3.—*Adelocephalia bicolor*, stage V (last), enlarged.



Author del.

LARVA OF ADELOCEPHALA BICOLOR, STAGES III—LAST.

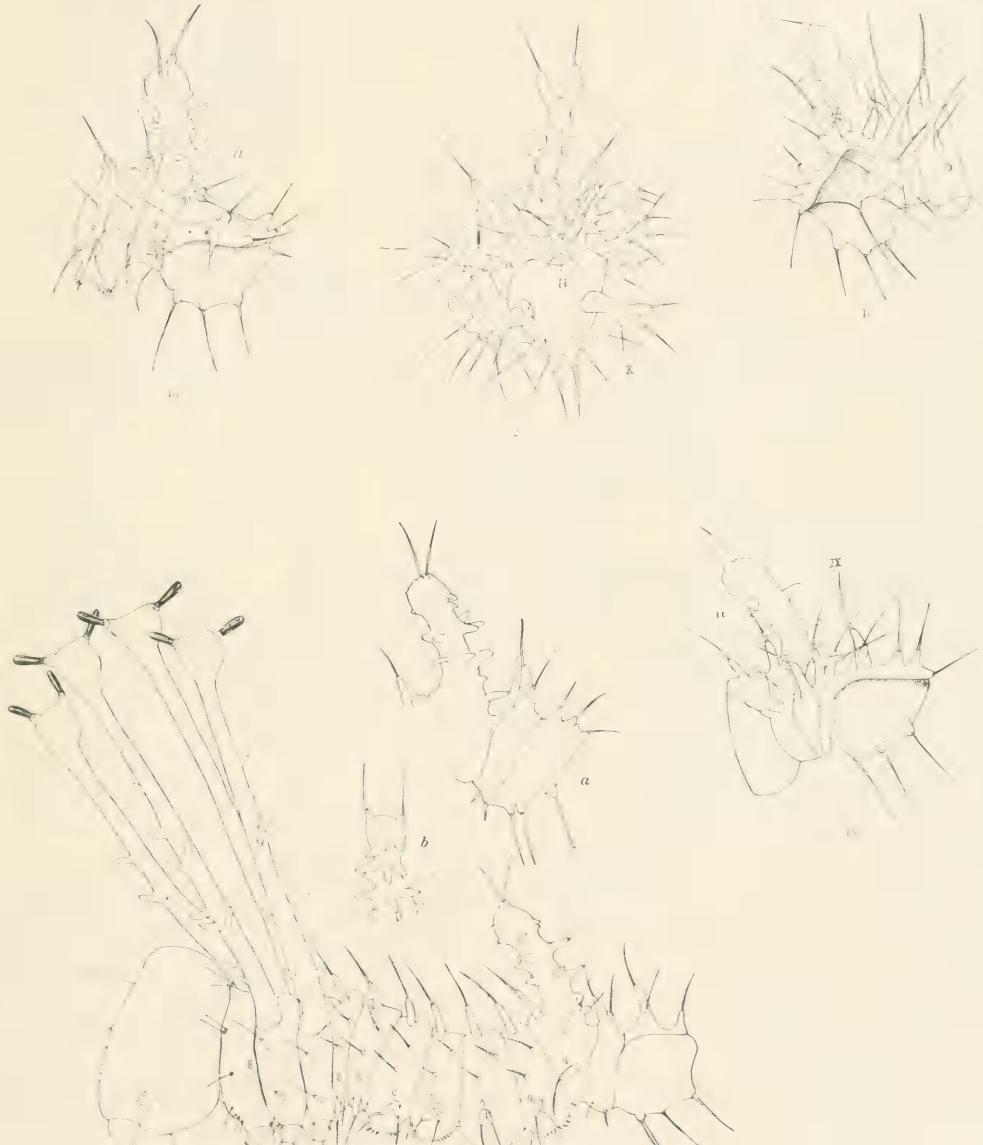




#### EXPLANATION OF PLATE XLVII.

FIG. 1.—*Syssphinx molina*, stage 1; *a*, end of body, with caudal horn; *b*, end of caudal horn seen from in front ending in two setae; *1b*, another view of end of the body showing the caudal horn; IX, ninth abdominal segment; *i*, the second dorsal tubercle of segment eight. 1c, another (side) view of end of the body showing the caudal horn, suranal plate, and anal leg; all highly magnified.

FIG. 2.—*Eacles imperialis*, larva, stage 1; *ii*, median double tubercles of the second series; VIII, eighth segment; IX, ninth segment; X, suranal plate.



Author del.

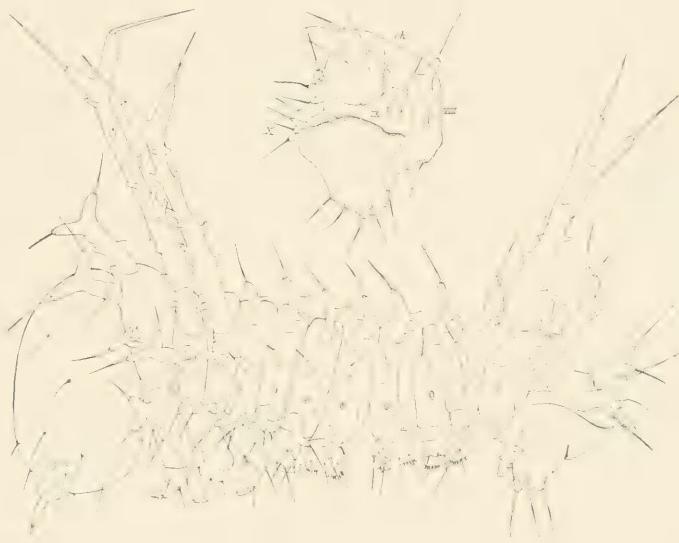
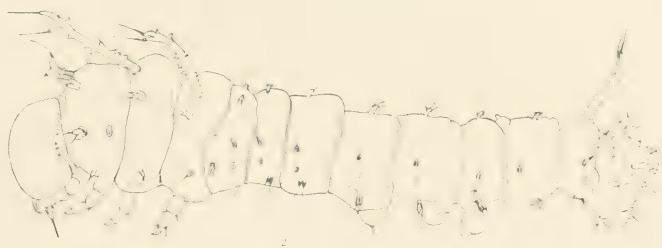
LARVA (STAGE II) OF *SYSSPHINX MOLINA*, 2, *EACLES IMPERIALIS*.



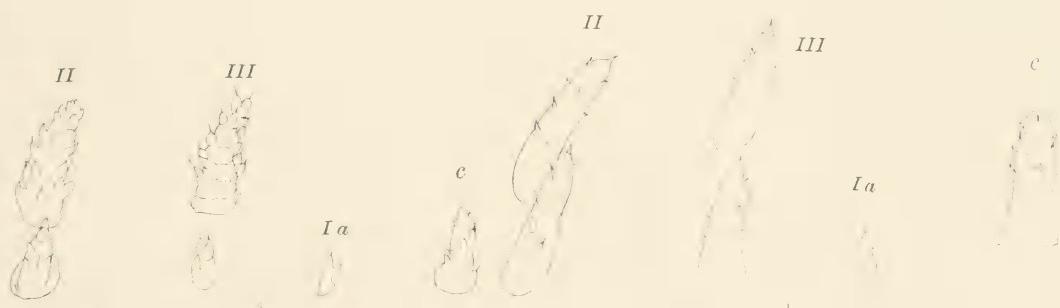


#### EXPLANATION OF PLATE XLVIII.

- FIG. 1.—*Eacles imperialis*, stage I; *ch*, caudal horn, highly magnified.  
FIG. 2.—*Eacles imperialis*, stage II, much enlarged.  
FIG. 3.—*Eacles imperialis*, armature of full-fed larva, first stage; I, II; second thoracic tubercles, *i*, *ii*; III, the same of the third thoracic segment; *Ia*, a dorsal tubercle of the first abdominal segment; *c*, caudal horn.  
FIG. 4.—*Eacles cacicus*, from Brazil; lettering as in fig. 3.



1



Author del.

LARVA OF EACLES IMPERIALIS (I, II) AND CACICUS.





#### EXPLANATION OF PLATE XLIX.

FIG. 1.—*Adelocephala argyracantha* [= *crocata*]; natural size; copied from Burmeister.

FIG. 2.—*Adelocephala isias*, stage IV, dorsal armature of the three thoracic and first three abdominal segments (the dorsal horn of the third thoracic segment omitted); 2a, stage V, the dorsal tubercles;  $a'$ , vestiges of the prothoracic ones;  $b'$ , second thoracic ( $i$  and  $iii$ );  $c'$ , third thoracic ( $i$  and  $ii$ ); 2b, dorsal tubercles ( $i$ ,  $ii$ ) on first and sixth abdominal segments; VII  $i$ , dorsal ( $i$ ) on seventh abdominal segment; 2c, armature of eighth and ninth abdominal segments, including the caudal horn; 2d, caudal horn and suranal plate of stage IV; 2e, suranal plate, dorsal view. From San Antonio, Tex.

FIG. 3.—*Adelocephala isias*, dorsal armature of first thoracic segment (I); second and third, II, III, and first two abdominal segments; 3a, of the last abdominal segments, including the caudal horn. From Brownsville, Tex.

FIG. 4.—*Adelocephala* from Brazil (see p. 14) th.  $i$ , prothoracic; th. 2*i*, th. 2*iii*, dorsal and subdorsal horns ( $i$ ,  $iii$ );  $a^1$ ,  $a^2$ , dorsal spines of first and second abdominal segments;  $c$ , caudal horn.

Author *et al.*

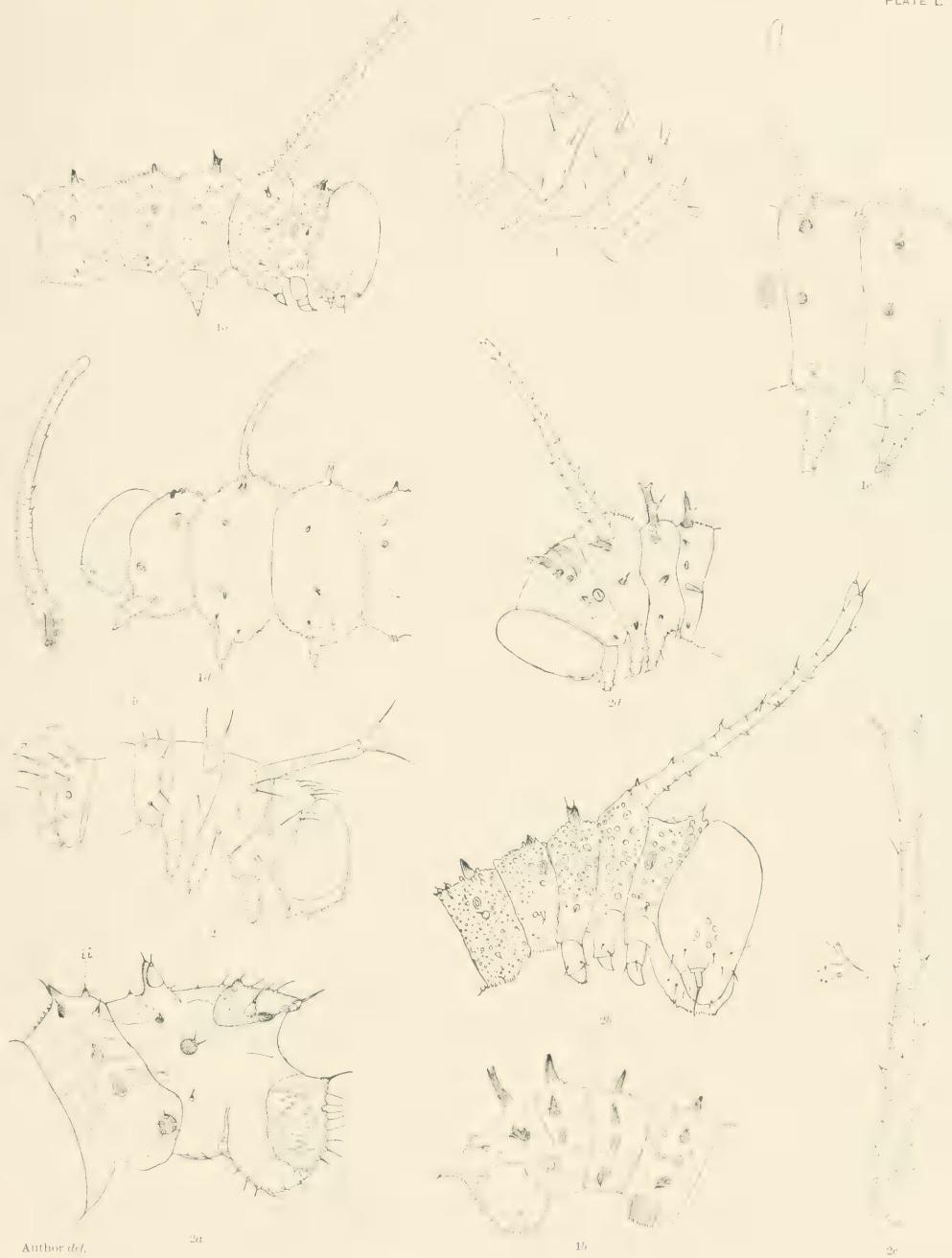
LARVA OF ADELOCEPHALA ARGYRACANTHA, ETC.





#### EXPLANATION OF PLATE L.

- FIG. 1.—*Anisota virginensis*, head and first four trunk segments of larva, stage I.  
FIG. 1a.—*Anisota virginensis*, head and first five trunk segments, stage III.  
FIG. 1b.—*Anisota virginensis*, end of body, stage III.  
FIG. 1c.—*Anisota virginensis*, second and third thoracic segments, full-grown larva.  
FIG. 1d.—*Anisota virginensis*, head and four trunk segments, and tubercles *i* (horn) and *ii* (at base of horn), full-grown larva.  
FIG. 2.—*Anisota stigma*, head and four trunk segments, and last three segments (viii–x) of stage I.  
FIG. 2a.—*Anisota stigma*, end of body, end of stage II (length of larva 10 mm.).  
FIG. 2b.—*Anisota stigma*, head and five trunk segments, stage III.  
FIG. 2c.—*Anisota stigma*, second thoracic horn, and the third (reduced) thoracic horn, stage III.  
FIG. 2d.—*Anisota stigma*, head and four thoracic segments, stage IV.



Author del.

2a

1b

2e

LARVA OF *ANISOTA VIRGINIENSIS* AND STIGMA.





#### EXPLANATION OF PLATE LI.

- FIG. 1.—*Anisota senatoria*, head and four trunk segments, stage III; *a*, third thoracic dorsal tubercle.
- FIG. 2.—*Anisota stigma*, second thoracic horn, stage II, with third dorsal thoracic tubercle; larva 70 mm. in length; also the same, stage III, with two views of third thoracic dorsal tubercle; and V, an aberrant, shorter, stouter horn.
- FIG. 2*a*.—*Anisota stigma*, *c*, right thoracic horn, deformed, short, but of the same thickness as its mate; *e*, tubercle *iii* (supraspinaeular), stage IV? *a*, third dorsal; *b*, abnormal second dorsal tubercle of a larva 12 mm. long.
- FIG. 2*b*.—*Anisota stigma*, end of body, stage III.
- FIG. 2*c*.—*Anisota stigma*, end of body, stage IV.
- FIG. 3.—*Anisota senatoria*, head and five trunk segments, stage I.
- FIG. 3*a*.—*Anisota senatoria*, head and four trunk segments, stage II.
- FIG. 3*b*.—*Anisota senatoria*, prothoracic and second dorsal horn of stage III, and second thoracic horn of stage V.
- FIG. 3*c*.—*Anisota senatoria*, head and four trunk segments, stage IV.



Author del.

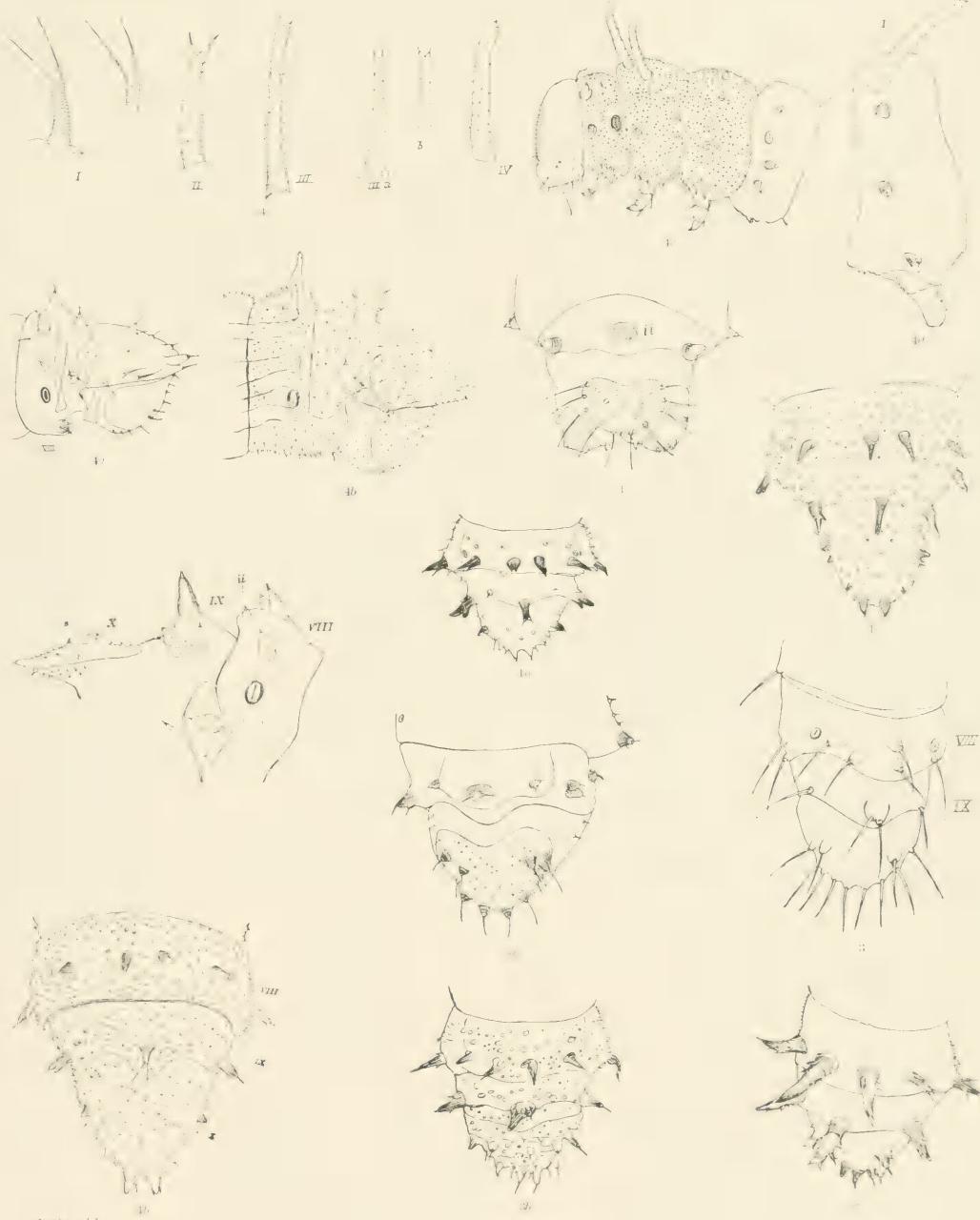
LARVA OF *ANISOTA STIGMA* AND *SENATORIA*.





#### EXPLANATION OF PLATE LII.

- FIG. 1.—*Anisota virginensis*, stage I, end of body, showing the median tubercle (*i*) on abdominal segment nine, and the anal legs.  
FIG. 1a.—*Anisota virginensis*. The same (without anal legs), stage III.  
FIG. 1b.—*Anisota virginensis*, last stage.  
FIG. 1c.—*Anisota virginensis*, last stage. The same, drawn from a blown (Elliott's) larva.  
FIG. 2.—*Anisota senatoria*, last stage (V), *i*, tubercle of second pair.  
FIG. 3.—*Anisota stigma*, end of body, stage I.  
FIG. 3a.—*Anisota stigma*, end of body, stage II; length of larva, 10 mm.  
FIG. 3b.—*Anisota stigma*, end of body, stage III.  
FIG. 3c.—*Anisota stigma*, end of body, stage IV.  
FIG. 4.—*Anisota rubricunda*, I, second thoracic horn of stages I, II, III, and IV; IIIa, end of stage III; length of larva, (3d stage) 21 mm.  
FIG. 4a.—*Anisota rubricunda*, end of body, stage II, side view.  
FIG. 4b.—*Anisota rubricunda*, end of body, stage III.  
FIG. 4c.—*Anisota rubricunda*, head and four trunk segments, stage IV.  
FIG. 4d.—*Anisota rubricunda*, second thoracic segment, last stage.



LARVÆ OF ANISOTA, SURANAL PLATE, ETC.

Ardizzone et al.





#### EXPLANATION OF PLATE LIII.

- FIG. 1.—*Anisota senatoria*, end of larval, stage I, showing suranal plate, from above; with tubercles *i*, and *ii*.  
FIG. 1a.—*Anisota senatoria*, end of larval, stage II, showing suranal plate, from above.  
FIG. 1b.—*Anisota senatoria*, *ii*, median double tubercle, end of stage III.  
FIG. 1c.—*Anisota senatoria*, *ii*, median double tubercle, end of stage IV, side view.  
FIG. 1d.—*Anisota senatoria*, *ii*, median double tubercle, end of stage IV, dorsal view.  
FIG. 1e.—*Anisota senatoria*, *ii*, median double tubercle, end of stage IV, dorsal view, ninth segment from same larva as 1c.  
FIG. 1f.—*Anisota senatoria*, *ii*, median double tubercle, end of stage V (last).  
FIG. 2.—*Anisota rubricunda*, end of body, stage I, dorsal view.  
FIG. 2a.—*Anisota rubricunda*, end of body, stage II, dorsal view.  
FIG. 2b.—*Anisota rubricunda*, end of body, stage III, dorsal view; *a*, median tubercle seen from behind.  
FIG. 2c.—*Anisota rubricunda*, end of body, stage V (last).  
FIG. 3.—*Endromis versicolora*, end of full-grown larva showing the small, short, double caudal horn (*ch*); also the suranal plate, with the anal legs *ad* on each side.  
FIG. 3a.—Caudal horn, seen from in front, showing its double nature, the tubercles being nearly separate.

Author del.

LARVÆ OF ANISOTA, SURANAL PLATE, ETC.





#### EXPLANATION OF PLATE LIV.

- FIG. 1.—*Citheronia regalis*, larval armature: A, stage I; B, stage II; *th*, thoracic horns; *lob*, that of the first abdominal segment I; *vii*, that of abdominal segment 7; *viii*, caudal horn, horn on 9th segment; *x*, armature of tenth segment.
- FIG. 2.—*Citheronia regalis*, stage III; *i*, *ii*, *iii*, horns of each thoracic segment.
- FIG. 3.—*Citheronia regalis*, stage III, end of body, side view, including caudal horn, suranal plate, and anal leg.
- FIG. 4.—*Citheronia regalis*, stage IV (next to last), armature of the thoracic segments, and of the 1st abdominal segment; 1st, 2d, 3d dorsal tubercles of abdominal segments 1-3.
- FIG. 5.—*Citheronia regalis*, last stage; tubercles *i*, *ii*, *v*, *vii* of each thoracic segment. *A*, dorsal tubercle of the first abdominal segment II.
- FIG. 6.—*Citheronia regalis*, last stage, abdominal segments 8-10; *s*, lateral tubercle of abdominal plate; *i*, caudal horn; *ii*, median or caudal horn of 9th segment.
- FIG. 7.—*Adeloceropeltis* sp. from Brazil, Pl. III, fig. 1; end of body, dorsal view of suranal plate.



Author del.

LARVA OF *CITHERONIA REGALIS*, ETC.





#### EXPLANATION OF PLATE LV.

- FIG. 1.—*Citheronia splendens*, head and four trunk segments.  
FIG. 1a.—*Citheronia splendens*, next to last stage, the last three segments of the body, showing the caudal horn, suranal plate, and anal legs.  
FIG. 1b.—*Citheronia splendens*, the same from above.  
FIG. 2.—*Citheronia laeocoon*; i, ii, iii, armature of the thoracic segments; *A viii*, of the 1st abdominal segment; *A viii*, caudal horn *h* and tubercle *ii*.  
FIG. 2a.—*Citheronia laeocoon*, suranal plate, from above.  
FIG. 3.—*Citheronia phoronea?* (Monlez, Brazil); thoracic horns, and *c*, caudal horn.  
FIG. 4.—*Citheronia sepulcralis*, head and first six trunk segments, last stage.  
FIG. 4a.—*Citheronia sepulcralis*, end of body, last stage, side view.  
FIG. 4b.—*Citheronia sepulcralis*, the same seen from above; *ii*, tubercle *ii* of 8th abdominal segment.



Author del.

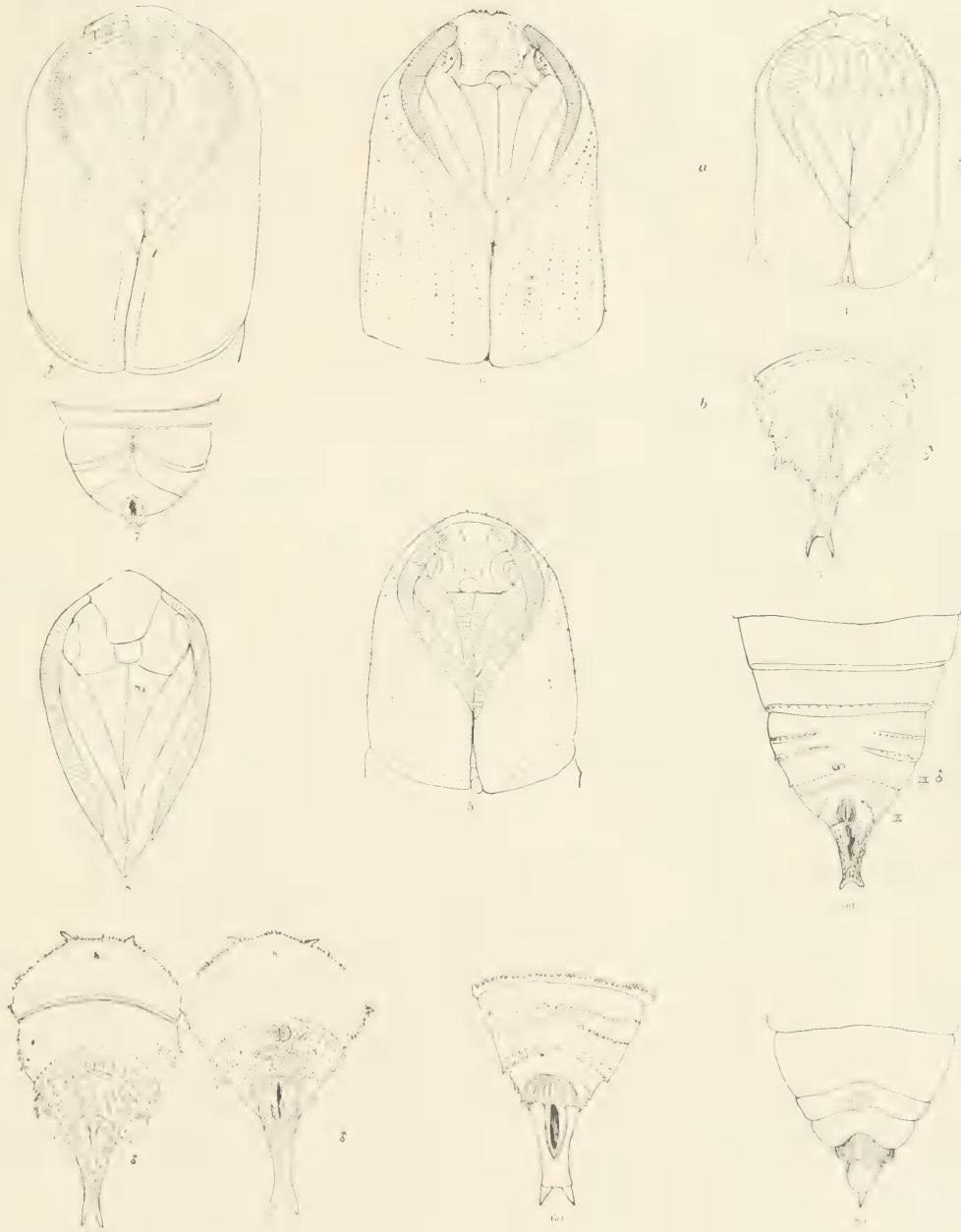
LARVA OF CITHERONIA SEPULCRALIS, ETC.





#### EXPLANATION OF PLATE LVI.

- FIG. 1.—*Anisota virginensis*, ♂, pupa, end of abdomen, with cremaster.  
FIG. 2.—*Anisota senatoria*, ♂, pupa, end of abdomen, with cremaster.  
FIG. 3.—*Adelocephalta bicolor*, ♂, pupa, end of abdomen, with cremaster.  
FIG. 4.—*Adelocephalta bicolor*, pupa from beneath, head and thorax.  
FIG. 5.—*Eacles imperialis*, pupa from beneath, head and thorax.  
FIG. 6.—*Eacles cacicus*, pupa from beneath, head and thorax.  
FIG. 7.—*Citheronia regalis*, ♂, pupa from beneath, head and thorax, and end of the abdomen, with the nearly atrophied cremaster.  
FIG. 8.—*Pauonia excavatus*, pupa, head from beneath, *mx*, maxilla.



Author del.

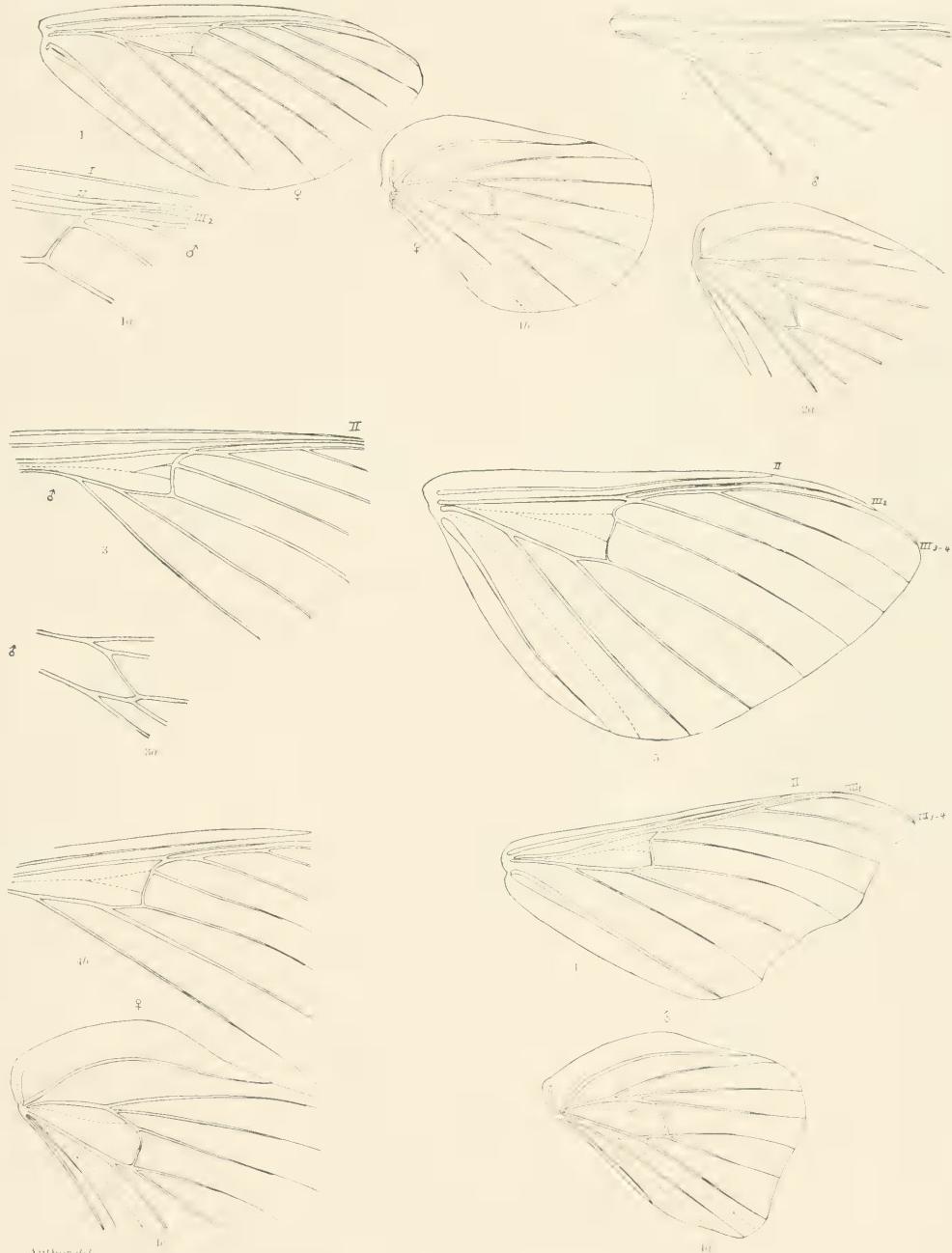
PUPA AND CREMASTER OF CERATOCAMPINÆ, ETC.





#### EXPLANATION OF PLATE LVII.

- FIG. 1.—*Adelocephala bicolor*, ♀, venation of fore wing; 1a, ♂ the same, enlarged; 1b, hind wing ♀.  
FIG. 2.—*Adelocephala cadiuus*, ♂, venation of part of fore wing; 2a, hind wing.  
FIG. 3.—*Adelocephala boisduvalii*, ♂, venation of fore wing; 3a, part of hind wing.  
FIG. 4.—*Syssphinx molina*, ♂, venation of fore wing; 4a, hind wing; 4b, fore wing ♀, 4c, hind wing ♀.  
FIG. 5.—*Anisota dissimilis*, venation of fore wing.



Author del.

VENATION OF ADELOCEPHALA, SYSSPHINX, ETC.





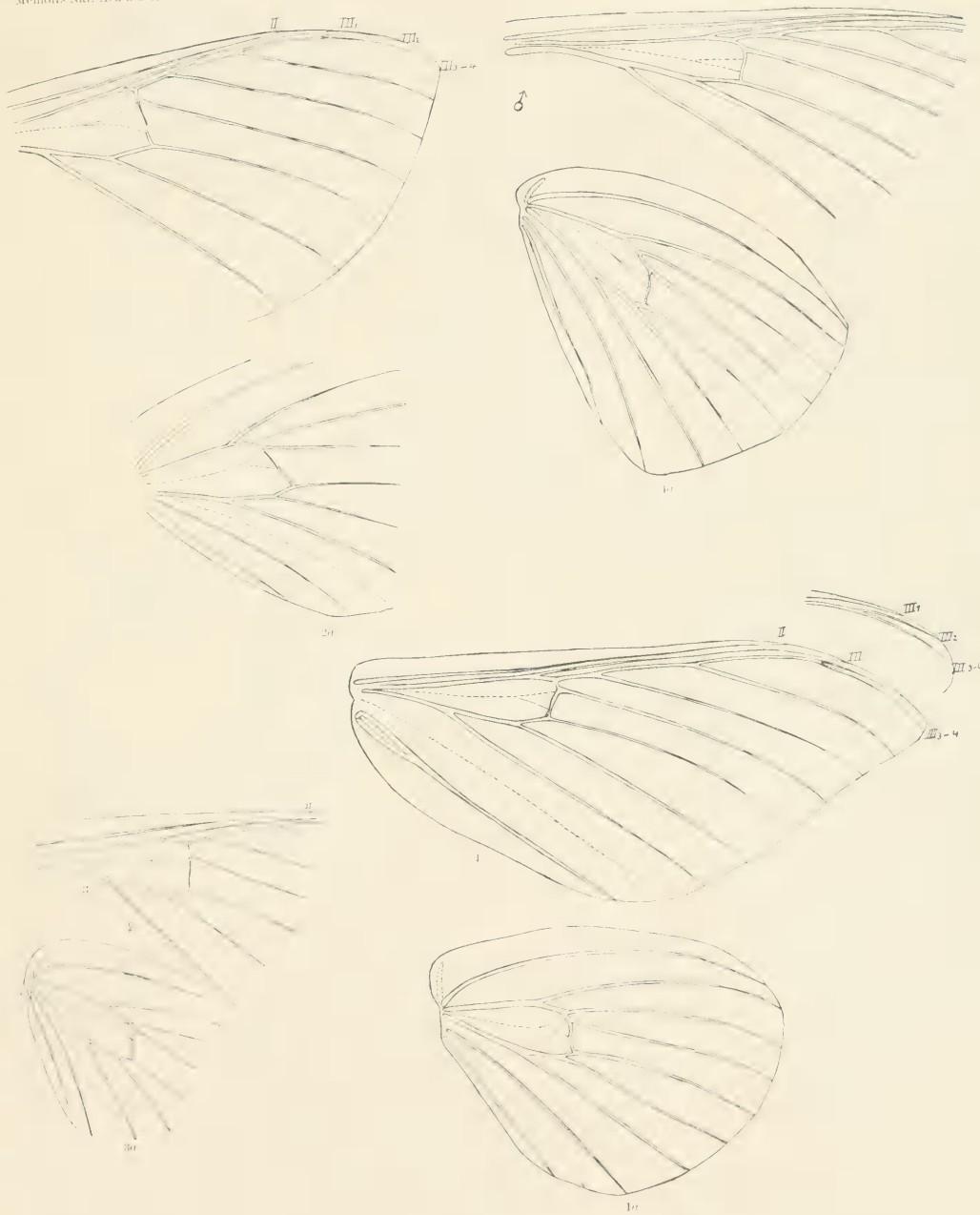
#### EXPLANATION OF PLATE LVIII.

FIG. 1.—*Citheronia regalis*, ♂, venation of fore wing; 1a, hind wing.

FIG. 2.—*Citheronia laocoon*, venation of fore wing; 2a, hind wing.

FIG. 3.—*Citheronia principialis*, ♀, venation of fore wing; 3a, hind wing.

FIG. 4.—*Citheronia sepulcralis*, ♂, venation of fore wing; 4a, hind wing.



VENATION OF CITHERONIA REGALIS, ETC.

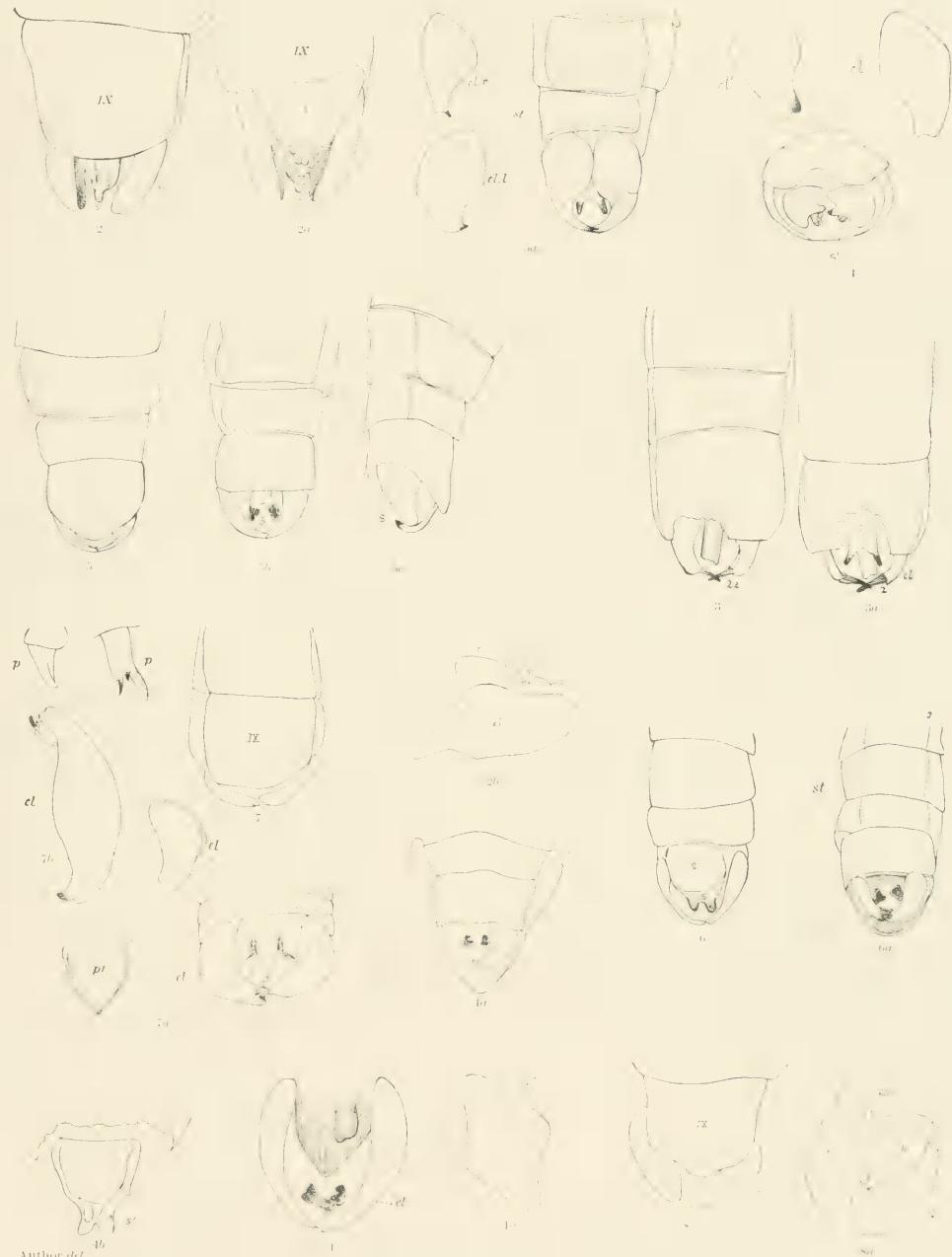
Author del.





#### EXPLANATION OF PLATE LIX.

- FIG. 1.—*Adelocephala bicolor*, ♂, genital armature, from beneath; *cl*, clasper; *1a*, side view of the same.  
FIG. 2.—*Adelocephala bisecta*, ♂, tergal view; *s'*, end of suranal plate.  
FIG. 2a.—*Adelocephala bisecta*, ♂, tergal view, end of body removed to show entire suranal plate (*s*), with its tip (*s'*).  
FIG. 2b.—*Adelocephala bisecta*, ♂, clasper (side view); *s*, suranal plate.  
FIG. 3.—*Syssphinx molina*, ♂, from beneath; *2a*, clasper.  
FIG. 3a.—*Syssphinx molina*, ♂, from above; *s*, basal piece of suranal plate; *cl*, clasper, with its solid black tip (2).  
FIG. 4.—*Anisota virginiana*, ♂, seen from end; *s'*, ends of the forked suranal plate; *cl*, clasper, from the outside; *cl'*, the same, seen from the inside.  
FIG. 4a.—*Anisota virginiana*, ♂, the genital armature, from beneath.  
FIG. 4b.—*Anisota virginiana*, ♂, the genital armature, under side of suranal plate, with the terminal fork (*s'*).  
FIG. 5.—*Anisota stigma*, ♂, end of abdomen, from above.  
FIG. 5a.—*Anisota stigma*, ♂, sternal view of claspers and forked tip of suranal plate; *cl*, *r*, right clasper; *cl*, *l*, left clasper; *st*, sternum.  
FIG. 5b.—*Anisota stigma*, ♂, a portion (tergite) removed to show the forked end of the suranal plate (*s'*).  
FIG. 5c.—*Anisota stigma*, ♂, end of abdomen, lateral view.  
FIG. 6.—*Anisota senatoria*, ♂, tergal view of genital armature, the tergite of segment nine having been removed.  
FIG. 6a.—*Anisota senatoria*, ♂. The same, from beneath.  
FIG. 7.—*Anisota rubricunda*, ♂, end of abdomen; *p*, penis; *pt*, penis sheath; *cl*, clasper-tip not shown.  
FIG. 7a.—*Anisota rubricunda*, ♂, sternal view; *s*, suranal plate bent down.  
FIG. 8.—*Citheronia regalis*, ♂, segment nine (IX) and clasper intact, dorsal view.  
FIG. 8a.—*Citheronia regalis*, ♂, sternal view of clasper (*cl*), harpe (*h*), with sternite of segment eight (VIII), and the suranal plate between the harpes.



Author del.

GENITAL ARMATURE OF CERATOCAMPINÆ.





#### EXPLANATION OF PLATE LX.

- FIG. 1.—*Eacles imperialis*, ♂, ventral view of end of abdomen; *p.* penis.  
FIG. 1a.—*Eacles imperialis*, ♂, lateral view of the same; *l.*, *cl.* clasper.  
FIG. 1b.—*Eacles imperialis*, ♂, end of abdomen, a portion removed; *s.* suranal plate.  
FIG. 1c.—*Eacles imperialis*, ♂, the same, seen from beneath, claspers fully exposed.  
FIG. 2.—*Citheronia regalis*, ♂, side view of genital armature; *cl.* clasper; *h.* harpe; *p.* penis.  
FIG. 2a.—*Citheronia regalis*, ♂, the same; *h.* harpe; *p.* penis and its sheath; *s.*, *s.* suranal plate.  
FIG. 2b.—*Citheronia regalis*, ♂, *p.* penis, showing the gutter at the end.  
FIG. 2c.—*Citheronia regalis*, ♂, suranal plate; *s.* basal portion.  
FIG. 3.—*Citheronia sepulcralis*, ♂.  
FIG. 3a.—*Citheronia sepulcralis*, ♂, genital armature, tergal view, genital armature, side view; *h.* harpe; *cl.* clasper.  
FIG. 3b.—*Citheronia sepulcralis*, ♂, the same, seen from beneath; *h.* harpe; *cl.* clasper.  
FIG. 4.—*Cressonia juglandis*, ♂, genital armature, from above.  
FIG. 4a.—*Cressonia juglandis*, ♂, genital armature, from beneath, lettering as before.  
FIG. 4b.—*Cressonia juglandis*, ♂, genital armature; *A.* suranal plate and terminal hook.  
FIG. 4c.—B, harpes, base and extremity.  
FIG. 4d.—*Cressonia juglandis*, ♂, genital armature; *C.* side view of suranal hook (*s.*); *h.* harpe.  
FIG. 4e.—*Cressonia juglandis*, ♂, genital armature; *D.* penis (*p.*); *p'*, its base.  
FIG. 4f.—*Cressonia juglandis*, ♂, genital armature; suranal hook; penis and harpe (*p.*).  
FIG. 4g.—*Cressonia juglandis*, ♂, the same, another side view.







#### EXPLANATION OF PLATE LXI.

FIG. 1.—*Adelocephala högei*, ♂.

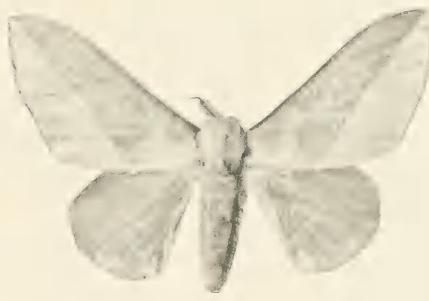
FIG. 2.—*Adelocephala cadmus*, ♂.

FIG. 3.—*Adelocephala montezumus*, ♂.

O



3



2



1

1, *ADELOCEPHALA HOGEI*; 2, *A. CADMUS*; 3, *A. MONTEZUMA*.













SMITHSONIAN INSTITUTION LIBRARIES

3 9088 00243288 8  
nhent qQL561.B6P2X  
pt. 2 Monograph of the bombycine moths